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Ships, Shipbuilders and Seamen!

"WHATEVER other contribution we may make to the prosecution of the war, that of ships must be first, because it is only by means of ships that other contributions can be successfully delivered."—*James A. Farrell, president, United States Steel Corporation.*

"It has become apparent to most of us in this war that the success of our efforts, the amount of force we can put into the war, depends not alone upon the army or the navy, and not alone upon any department of the Federal Government. To win the war requires the enthusiastic support of the great bulk of the people of the country in a very important industry. . . . The output of ships in American shipyards depends more upon the supply of labor and the continuous employment of that labor than any other fact. The use of these ships, when once built, is going to depend more upon the supply of seamen and officers and the services of longshoremen in loading and unloading them than any other factor in the situation."—*Raymond B. Stevens, vice-chairman, United States Shipping Board.*

Speed Up the Emergency Fleet

ALTHOUGH plans for the standard steel fabricated ships, which will form a large part of the Government's emergency fleet, were fully developed last June, it was not until a month ago that contracts for the construction of any of these ships were placed, and construction of the three great yards in which they will be built has now only just begun, while the laying of the first keel is still a matter of the future. Enormous as these projects are, a delay of from three to four months in the initial stages of their development through differences between the Shipping Board and its subsidiary organization, finally resulting in an almost complete change in the personnel of the two bodies, is a matter that can be condoned only by putting forth every effort for the speeding up of production now that the work is actually begun.

When the Government emergency fleet was first proposed the former chairman of the Shipping Board predicted that the first of the standard wooden ships would be available for service by November 1, and that after that date the fleet would rapidly increase week by week. As a matter of fact, not one of the Government standard ships, of either wood or steel, is yet in the water, and the earliest deliveries cannot be expected before next spring.

So much for the delays which sometimes appear inevitable in a national crisis by the clogging of Government departmental machinery with misfits, incompetency and political interference. Since harmony has been restored, the outlook is brighter. Vast improvements in the speed of production have already been made by many of the older and some of the new shipyards, and the ships under contract that were commandeered by the Government are coming off the ways in increasing numbers every week. To speed up and promote in every way the country's shipbuilding the Shipping Board has appointed a special production board, consisting of Charles Piez, president of the Link Belt Company, Chicago, chairman, and Charles Day, electrical engineer, Philadelphia; Arthur Mason, erecting engineer, Chicago, and Frank Kirby, naval architect, New York. In surveying the shipbuilding field this committee is authorized to recommend any improvements in methods of construction or in shipbuilding materials which will eliminate delays. Increased production from now on, however, will undoubtedly depend far more on the labor question than upon the question of shipbuilding facilities or supplies. In fact, shortage of labor and labor troubles form the most important obstacles now facing the Government shipbuilding programme.

A New Era in Shipbuilding

GREAT BRITAIN built her first 8,000-ton standard steel ship in less than six months, and it is predicted that later vessels of the same class will be produced in from four to four and a half months. An 8,800-ton steel cargo steamship was recently turned out in an American shipyard in less than five months, but it remains for the actual building of the fabricated steel ships in the new Government yards now being erected to show what is actually possible in the rapidity of production of standardized steel ships. If expectations are fully met, and there is every reason to believe that they will be, if not surpassed, a new era in shipbuilding, and one that is characteristic of American enterprise and ingenuity in gigantic intensive building operations, will have dawned.

In the case of the fabricated ships, contrary to the usual practice in shipbuilding, 82 percent of the hull work, including riveting, will be completed in structural steel shops inland, so that when the fabricated parts of the ship reach the shipyard on the seaboard only 18 percent of the work will remain to be done in erecting the ship. Not only will accurate molds and templates of every plate and shape in the vessel be supplied to the structural shops, so that every piece of metal that goes into the ship, including such parts as the bossing around the stern tube, can be accurately cut, shaped and punched in the shops, but also as much of the riveting as the limits in size of fabricated sections that can be transported to the seaboard will allow will be done at the structural shops. The work at the yards, therefore, is reduced to the erection and riveting of the fabricated sections.

To aid in the speed of fabrication, the model of the ship is such that a maximum amount of straight line work is involved, the usual sheer and camber of decks, an inheritage of the early wooden shipbuilding days, being discarded and structural shapes substituted for the special shipbuilding shapes. In the case of the machinery, contracts are

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let to an engine builder for the complete equipment for the engine room, including the main propelling engines, shafting, auxiliaries and piping to be delivered accurately fitted and ready for installation in a minimum of time. Similarly, the complete equipment of the boiler room, including the boilers, auxiliaries and piping, is to be supplied under one contract by the boiler manufacturer, ready for immediate installation in the ship.

Under this scheme the shipyard with a maximum number of building ways and adequate transportation facilities and appliances for handling material becomes simply an assembling or erection yard, depending for its success upon a carefully planned schedule for the fabricating of the various parts of the structure with extreme accuracy and for their delivery at the shipyard at exactly schedule time, which differs little except in volume from the kind of work which the steel structural shops of the United States have been carrying out successfully for years in connection with bridge and other structural work.

Lloyd's Approval of Concrete Ships

LLOYD'S recent approval of plans for the construction of several reinforced concrete ships with a view to classification by the society means that the ferro-concrete, seagoing, self-propelled vessel has become—within certain limits of size—a practical proposition. Now that the basic principles upon which this form of shipbuilding rests have been fully accepted, the problem resolves itself into a question of how far such a design may be developed safely in its application to larger ships. The plans already approved by Lloyd's cover a number of non-propelling barges, some of which are designed to carry as much as 500 tons deadweight, and a motor vessel for coastwise trade between Great Britain and Scandinavian countries. These vessels will be built in the United Kingdom and Norway under the inspection of Lloyd's surveyors and plans for other similar vessels, but of larger carrying capacity, are now under consideration.

The Nine Million Dollar Plant At Fore River

THE new plant of the Fore River Shipbuilding Corporation located a few miles south of Boston, will, in the course of a few months, be the greatest destroyer plant in the world. It will be erected by the Aberthaw Construction Company, of Boston, at a cost of over $9,000,000 (£1,850,000).

This is by far the biggest thing of its kind ever attempted in the United States, particularly in view of the fact that the plant will be practically finished at the beginning of 1918. The complete development will comprise a large number of small destroyer slips and the necessary manufacturing buildings, the latter having an aggregate floor space of more than 2,000,000 square feet.

To gain some idea of this tremendous undertaking compare it with the contracts for building the great army cantonments, the largest of which was two million less than the job just awarded the Aberthaw Company. It should also be noted that the present development is a permanent proposition, the work being almost entirely reinforced concrete, whereas the cantonments were temporary structures built mostly of wood.

After the completion of the plant the programme calls for delivery by the Fore River Corporation within two years of at least 46 destroyers. These will cost $1,500,000 (£308,000) each, or a total of $69,000,000 (£14,168,000).

In addition to the main plant outside of Boston, there will be erected a $2,500,000 turbine plant at Buffalo, N. Y., and another $1,500,000 plant in Providence, R. I. The equipment from these plants will be shipped to Fore River as soon as completed.

The construction of the plant itself will require more than 4,000 men, and the Aberthaw Company plans on having this full quota on hand by November. For the construction of the ships themselves the Fore River Shipbuilding Corporation will need from 8,000 to 10,000 men at Quincy, 3,500 at Buffalo, and 1,000 at Providence. They will endeavor to obtain part of the necessary quota by offering positions to Aberthaw men who are at present working on the construction of the plant.

Material for the ships will not be lacking, since the priority board has given the destroyer builders preference over all other concerns working for the Government, even over shipbuilders constructing the merchant fleet. Furthermore, the Carnegie Steel Company has rolled steel for thirty-two destroyers in two months, and can, therefore, readily make delivery for the ships to be built under the new programme.

The Return to the Reciprocating Engine

ONE of the most interesting features in connection with the new shipping programme is the wholesale return to the reciprocating engine as a main drive. This coming immediately after the successful demonstration of the advantage of gear turbine drive makes this point all the more noticeable. The answer, from what we can learn, lies in the fact that the gear-cutting capacity of the country is taxed to the limit. Deliveries are therefore prohibitive, whereas many plants are in a position to turn out reciprocating engines on record time.

While this is all very true with regard to prime movers, the same arguments cannot be advanced in regard to the auxiliaries, yet there seems a marked tendency throughout the present programme to adhere to reciprocating sets exclusively. Reliability is paramount in all marine work. Our own and foreign navies have appreciated this, and have switched over from reciprocating engines to turbines wherever possible for this one reason. The merchant ships that will sail the war zone will be equipped with apparatus, such as forced draft fans, that will be called upon to start up from rest at a moment's notice—and keep running. The turbine is obviously better adapted for this duty than the reciprocating engine.

Among the arguments one hears advanced as to why reciprocating engines should be used in this new programme is that the operating engineers will be more accustomed to them than to turbines. But will the man that will necessarily be called upon to operate these be really experienced with any types of engine? It would appear that with the present scarcity of skilled labor and the draft we will be compelled to man our ships to a great extent with green men. These men will have to be educated: then why educate them primarily in an obsolete school? Again, it has always been our impression that the modern small turbine requires much less attention than a reciprocating engine. If attention is needed for a reciprocating engine, will these green men be capable?

From an efficiency standpoint there exists a considerable difference of opinion as to what is the best type of apparatus to install. We quote from an article published by the Society of Naval Engineers in 1912 in connection with comparative tests that were made at Annapolis on turbine versus reciprocating pumps: "When pumping warm water there is little difference between the economy of this centrifugal pump and the simplex pump." It is true that the pumps in question were of larger capacity than will be required for the merchant marine, but even if the reciprocating engine does show up better on test, the question of maintenance of the initial efficiency must

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be considered. Quoting again from this same article: "Reciprocating pumps decrease steadily in efficiency, due to wear, while the centrifugal pump will probably change very little in this respect." Another point with regard to this efficiency question: if the exhaust can be utilized either in a feed water heater or the low pressure receiver, any net difference in efficiency between the two will have no appreciable effect on the coal pile. It is proposed to install forced draft sets in the emergency vessels for use in the war zone only. If the exhaust from these forced draft sets is led to the low pressure receiver, the pressure in this receiver will be automatically raised, which is just what is wanted for the higher speed requirements.

Regarding weight and space occupied, the turbine drive has unquestionably the advantage. For forced draft sets, for instance, if the figures we have before us are correct, there is approximately a saving of 1,000 to 1,500 pounds per boat. There is also a big saving in generator sets, but in forced draft sets, where it is proposed to operate them only as an emergency, the difference in water rate can be of no importance, and the saving in space and weight should, therefore, receive very serious consideration. The less weight and space taken up by machinery of any kind means that much more food for our own troops and those of our Allies.

It would be foolish for anyone to argue in favor of wholesale and indiscriminate adoption of steam turbines for all auxiliaries, but it would appear that the small steam turbine is not receiving the consideration it should for a lot of this work. First cost, of course, must enter into this argument. We have no figures on which to base any statement, but from figures from other installations with which we are acquainted it would appear that the turbine should have the advantage. However, this is purely a commercial proposition and must be decided between the shipbuilder and manufacturer.

What is the Operating Engineer to Expect from Superheating?

FOR the operating engineer, the man who has "to sleep with the job," the average marine engine, working with saturated steam, possesses no uncanny properties. What, then, will happen when his vessel is converted to superheated steam operation or he is transferred to a vessel so designed and constructed? Is he to be called upon to be shipmates with an engine that is possessed of peculiarities, in dealing with which his former experience counts for but little? It may prove interesting to see just what he is going to experience.

In raising steam an occasional opening of the drains on the superheater headers will be the only additional change in the usual procedure. With steam up on all boilers, the main stop valves are all opened, and steam passes through the superheater pipes, going to the throttle at a temperature some 200 degrees higher than when it left the main stop. On opening the throttle, the familiar "mushy" sound of the steam passing to the engine is missing, instead one hears the distinct hiss of absolutely dry steam, and as the vessel gains headway and revolutions increase, this change becomes more noticeable.

It frequently happens that the engine that was formerly turning up 80 or 85 revolutions per minute is now turning up on an average of 82 to 87 revolutions per minute, and, whereas it was formerly necessary to open drains all around and at times impossible to close the low pressure drain for a considerable period, we find such procedure no longer necessary. It may be found necessary to speed up the circulating pump slightly to hold the surface condenser to its duty.

Perhaps the engineer has been accustomed to running with very snug rings and he is fearful lest these should "seize"; on the other hand, and if he slacks up on them he feels that he may have leakage and lose in efficiency. This same engineer will put saturated steam pressure on a line that he has seen leaking slightly under water pressure, well knowing that the line will prove tight under steam. In the same way a ring fit that would permit of steam leakage saturated will be steam tight under superheated steam.

To compensate for the lubricating moisture under saturated steam, his vessel is now equipped with a force feed oil pump, introducing oil into the engine at the high pressure chest. This oil, which should be high grade, superheater oil, is taken out by either a gravity or pressure filter, the cleaning of which calls for half an hour's attention every thirty-six hours in the case of some gravity device operating in conjunction with an engine developing 3,000 indicated horsepower. Twenty minutes' attention to the pressure filter (installed between the pump and the feed water heater) every four or five days will, in a similar manner, keep the boiler free from oil. This matter of oil in the feed is one that the average engineer views with suspicion, unless he is operating a jet condenser and the condensate is pumped overboard. The fact, however, that boilers can be kept entirely free from oil is not based on a few isolated installations, but upon the experience gained on something over 2,000 vessels manned by crews of all nationalities and in every form of service.

In the blowing of flues, the blower operates the same as with saturated steam, except that by using superheated steam in the operation, the flues are cleaned more satisfactorily and the accumulated soot is blown out as soot. When saturated steam is used for this purpose the soot is often impregnated with moisture and the greater bulk of that escaping from the flues deposits by gravity in the soot pockets, thereby stopping up the lower rows of flues.

Furthermore, the superheater elements, while offering retardation to the draft, do not present a surface that is as potent in depositing soot during the process of combustion as is that presented by the average three or four turn retarder. Such being the case, there is less accumulation of soot in the same period, when the flues contain superheater elements instead of retarders.

Suppose it becomes necessary to plug a flue, steam is shut off the superheater at the main stop or from that branch of the superheater on the affected portion of the boiler, the unit whose elements project into the disabled flue is withdrawn by unscrewing two nuts, dummy ends are inserted into the superheated and saturated headers, and the nuts again set up—altogether a ten or twelve minute operation.

By the use of packing suitable for high degree superheat no trouble will be experienced with leakage or the scoring of the rods. It should be borne in mind, however, that as in saturated jobs the packing should be carefully put in and set up.

To the up-to-date engineer, considering the fuel saving effected, the slight additional care required by the superheated plant is, or should be, a negligible item. The elements essential to the successful operation of marine prime movers, by highly superheated steam, are all available at the present time; i. e., a proper design of superheater; material to withstand this high degree of superheat and a grade of oil that will not lose its lubricating properties at high temperatures.

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The Science of Naval Architecture*

Address Delivered Before the Franklin Institute by the Chief Constructor of the United States Navy—History of Development

BY DAVID WATSON TAYLOR, D. ENG.†

THE art of shipbuilding was undoubtedly developed at a very early stage of the history of the human race. The earliest record of a ship, as distinct from a boat, canoe or other small craft, is found in Egyptian carvings of a date about 3000 B. C. But the science of naval architecture, like so many other branches of science, developed slowly, this science, as now accepted, being mainly a development of the last hundred years—we may almost say of the last fifty years.

The famous Swedish naval architect and shipbuilder, Henry de Chapman, published a treatise on shipbuilding in 1775. As late as 1820 we find Doctor Inman, the head of the Royal Naval College and School of Naval Architects in Portsmouth Dockyard, England, publishing a translation of Chapman for the instruction of English students of naval architecture. Chapman's work, so far as it deals with the science of naval architecture, consists largely of empirical rules, although it was far in advance of his day, and much of it is still applicable to sailing ships. In some respects his ideas were largely erroneous, an example being his theories regarding resistance of ships. In fact, it was not until a hundred years after Chapman's time that the science of naval architecture was enriched by sound theories concerning this important branch.

In Ruskin's Day

Dealing with the sailing vessels concerning which Chapman wrote, Ruskin said:

"Take it all in all, a ship of the line is the most honorable thing that man as a gregarious animal has ever produced. By himself, unaided, he can do better things than ships of the line: he can do poems and pictures and other combinations of what is best in him. But as a being living in flocks and hammering out with alternate strokes and mutual agreement what is necessary for him in those places, to get or produce the ship of the line is his first work. Into that he has put as much human patience, common sense, forethought, experimental philosophy, self-control, habits of order and obedience, thoroughly wrought handiwork, defiance of brute elements, careless courage, careful patriotism, and calm expectation of the judgment of God as can well be put into a space 300 feet long and 80 feet broad, and I am thankful to have lived in an age when I can see this thing done."

This is what Ruskin thought and wrote years ago of the ship of his day. His words are even more true of the ship of our present day and generation. His 300 feet of length has trebled, and the size of such a ship, as measured in terms of weight, has grown nearly ten times. These modern ships have been made possible by the development of the science of naval architecture. This science, alone and unaided, without parallel development in practically all of the arts, sciences and trades, could not have produced these ships; but, so far as the ship itself is concerned, all the great progress in every branch of science and industry could not have produced this concentrated embodiment of human intelligence without the development and advancement of naval architecture or the theory of shipbuilding, a branch of applied science which calls upon and draws from an exceptional number of the arts and sciences.

The modern battle cruiser, whose building is just being undertaken in this country, is an excellent example of the mutual agreement and coördination necessary between all the arts and sciences in the work of the naval architect. These vessels of ours will be of 35,000 tons displacement and will be capable of a speed through the water of some 35 knots, or a little over 40 statute miles per hour. To drive this mass at this speed there will be required a machinery installation capable of delivering 180,000 horsepower. The vessels are 850 feet in length; they will carry ten high-powered 14-inch guns as a main battery, with the addition of a large number of guns of smaller caliber, to say nothing of the torpedo tubes.

Sciences Involved in Shipbuilding

Let us consider very shortly a few of the sciences involved when we undertake to build such a vessel. It is hardly necessary to say that this undertaking would not have been possible without the slow, steady development, through the ages, of the various theorems of pure mathematics, which, in their applied forms, have been necessary to material progress in the various branches of engineering. In addition to its general application, mathematics has made possible the modern systems of control of the firing of the great guns, which permit them, with a considerable degree of accuracy, to drop a shell weighing a ton, on a comparatively small target at a distance of 12 to 15 miles. This accurate control of fire is based largely on instruments or mechanisms which permit the instantaneous solution of problems containing as many as half a dozen variables.

Likewise, these ships could not be possible without the aid of astronomy, for it is through the development of that science, and through the experimental results made possible by it, that the various navigational instruments can be utilized to permit a sure and safe passage of the ship from one point of the earth's surface to another.

Chemistry has played its part, not only in its general contributions to all engineering progress, but also in its solution of specific questions and difficulties such as are involved in the manufacture of propellant powders and high explosives in forms that may be safely handled and carried on such a vessel until the selected moment for turning loose their destructive forces. Chemistry, also, through its particular manifestation in the form of metallurgy, has played one of the most important parts, by providing numerous varieties of steel, ferrous alloys and nonferrous metals, which are used in the various parts of the ship and its equipment, many of these having been developed solely for the use to which they are put in such vessels as these.

Physics, in its various branches, has played a prominent rôle. In optics it has given us the theories of and has made practicable the various instruments which, in con-

* Address delivered before Franklin Institute, Philadelphia, Pa., on May 16, when Rear Admiral Taylor was presented with the Franklin medal.

† Rear Admiral, United States Navy, Chief of Bureau of Construction and Repair.

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junction with fire control systems, make possible the accurate firing of guns and torpedoes, without which such a vessel would have no *raison d'être*.

Acoustics has played its part in the solution of many particular problems and difficulties, for, in the same way that coördination has been carried out in constructing the ship, the most complete and harmonious coördination of all parts of its organization are necessary in her hour of trial by battle. This is rendered possible only by the most perfect means and instruments of communication throughout all parts of the vessel. These systems of communication must be such that they will not break down in the midst of the noises and confusion of battle, or because of the high mental tension at such times of the personnel using them.

The sciences of physiology, medicine and hygiene must likewise play their part, for, during the long years of peace each of these vessels must be the healthful and, as far as possible, the happy home for anywhere from 1,000 to 1,500 men. This means that what we term in the navy "berthing and messing" facilities, or what in civil life would be referred to as the "housing and feeding" conditions, must be based on the most modern scientific principles. Likewise, to insure efficiency in battle, the design must take careful cognizance of what these sciences have taught us as to the limitations of human endurance when working at high pressure under adverse conditions. Nor do we stop at this point, for there is provided, in addition, a completely equipped medical establishment or hospital, including operating rooms, isolation wards for contagious diseases, special examining and treatment rooms, dental facilities, etc.

Branches of Naval Architecture

Without further enumeration of the many other branches of science and engineering which necessarily enter into the design of one of these great ships, let us consider more closely the principal branches of naval architecture proper. This is, broadly speaking, the division of engineering which enables us to make use of accumulated progress and knowledge to produce one workable and efficient assembled unit in the form of a ship. Its branches closely parallel the primary operations in the design of such a ship as has been described. Given the fundamental requirements of the design, which in the naval service we term military characteristics, and which consist of a brief statement of the results which it is desired to obtain with the completed vessel in service, it is first necessary to make an estimate of the size of the ship which will permit a solution of the design problem. The first estimate or approximation must be based largely on previous practice and experience. Before the development of naval architecture, in its modern sense, the necessity usually involved rather slow, step-by-step progress from one ship to another. Naval architecture has now taught us how to make these steps much greater, so that during the last quarter of a century advances which would have been bold to rashness at an earlier time have become almost routine. The rule of step-by-step progress referred to above has at least one remarkable—we may almost say astonishing—exception. Some sixty-five years ago a famous English civil engineer and bridge builder turned to shipbuilding. Maintaining that the larger the ship the more economical and efficient her operation, Brunel attracted large capital and in association with Scott Russell, the shipbuilder and naval architect, finally produced the *Great Eastern*, which was indeed a giant by a pigmy when compared with the other iron steamships of her day. Her keel laid in 1854, launched in 1858 after many difficulties, and put in service in 1859, the *Great Eastern* was not a commercial success. She fell short of the expectations of her designers in many respects. The successful completion even in five years of such a vessel was truly a remarkable accomplishment, but her size was ahead of her day, and it was not until 1899 that we find it again reached. As already stated, progress is more rapid nowadays than heretofore, but even now naval architecture would hardly enable us to take, with confidence, such a leap as the *Great Eastern* promoters undertook.

Detail Problems

When in the early stages of a design we have, based on previous practice and experience, reached a first approximation to the size of the vessel, it is next necessary to examine in detail the problems of strength, stability, resistance and propulsion of the ship. These represent broadly the main divisions of our subject. Naval architecture, as a whole, and its branches, like engineering generally, has not yet become an exact science, and in some respects it appears impossible that this will ever be attained. The strength and stability of ships, for example, should be such as to enable them to withstand, under all conditions, the waves of the sea, but the latter are infinite in variety, and the attempt must be to provide for any manifestation arising from this variety. It is therefore not possible in a new problem to lay down an exact condition of water surface, and say that if our ship can stand this condition it can stand all others. The best we can do is to make an approximation of the most severe condition, based on previous accumulated experience and observation. There have been made many thousands of observations on sea waves, but there is yet no complete agreement in regard to their limiting characteristics, such as length, height and the relations existing between these dimensions.

About the middle of the last century Rankine gave us the first complete mathematical theory of the formation and character of waves, known as the trochoidal theory; his result had, however, been largely predicted by Grestner more than sixty years before. Although Rankine's theory does not explain and is not entirely consistent with all phenomena of this nature, it is generally accepted today as a reasonable and convenient approximation of the facts, and it is usually upon stresses due to waves such as result from Rankine's theory that we have our determinations of strength of vessels.

Strength of Ships

We find that from the very beginning of practical shipbuilding the problem of strength was recognized in concrete form, for in the very first ship of which we have historical record its picture shows what we now term a "hogging" girder, which was provided to take the strains resulting from the variation between distribution of weight and distribution of buoyancy. It was the existence of these strains and the fact that they increased with increase in length of ships that operated to limit the length, and consequently the size, of ships during the era of wooden shipbuilding, as it was then, and still is, impracticable to develop the full strength in end connections between contiguous wooden members. The introduction of iron and steel in conjunction with the development of methods and mechanisms for riveting has made the modern ships possible. For many years the provision of the necessary strength depended largely on rule-of-thumb methods and step-by-step development from one ship to another. Such methods, of course, led in the majority of cases to one of two results: either deficiency of strength or excess of strength. For any structure erected on shore the latter fault is not necessarily a serious one, except from the point

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of view of cost. On a ship, however, too much material is almost as grave an error as too little, for every ship is built to perform some distinct service, and, as a floating body, can carry for all purposes only the equivalent of the weight of water which it displaces. Every pound which goes unnecessarily into the structure of the ship itself is a dead loss to the aim or object for which the vessel is designed. The modern theory of longitudinal strength for a vessel, as based on many years of observation and experiments, has its origin in the simple fundamental theories of strength of beams or girders. The ship's structure as a whole is considered as a built-up girder with upper and lower flanges and connecting webs. This girder is assumed to be supported on a wave of length equal to that of the ship. The height of this wave is assumed to have various relations to its length, depending upon the magnitude of that length, but for the majority of cases this relation is taken as one to twenty. This girder is then assumed to be supported in a manner represented by the buoyancy curve of the ship when floating on such a wave. The form of this buoyancy curve will, of course, vary with the position of the ship in relation to the crest and hollow of the wave, and in important strength calculations it is redrawn for at least two, and sometimes as many as six, positions. The loading of the girder is represented by the loading of the ship, including its own weight, that of permanent installations, such as propelling machinery, etc., and that of the variable or useful load carried. By successive integrations and the use of the simple beam formula we then arrive at the figures representing stresses and strains in the theoretical girder. Some experiments have been made from time to time, notably those of Biles in 1903, to check the accuracy of the results obtained by this method, but, due to the cost and magnitude of such experiments, there have never been collected sufficient data to enable us to say how accurately these results do represent the actual stresses in the ship in service. Accordingly, we are still largely dependent on comparing the figures obtained by this method for the new ship with those obtained by the same method for previous ships that have shown adequate strength in service.

Possibly due to the fact that our standard wave is not so steep as waves having the length of short ships, and steeper than waves having the length of long ships, it seems to have been thoroughly established by experience that, with the method outlined above, it is safe to allow larger stresses in large and long ships than in short and small ones. If, for instance, we find that by this method a small vessel in service shows satisfactory results when her figured standard stress is, say, six tons in compression and eight tons in tension, and shows indication of weakness if these figures are materially exceeded, and we would find that also in service a very large and long ship would show no signs of weakness with calculated stresses as high as ten tons in compression and twelve tons in tension. This principle appears to have been acted upon, though the scientific principles underlying it were not fully understood, even in the early days of iron shipbuilding. This was brought out about fifty years ago, when our modern methods of figuring strength were first applied to ships built in accordance with the then existing rules of the classification societies, with the result that the large ships of that day were found to have indicated stresses in extreme cases nearly five times as great as those found in small ships.

There are, of course, a very large number of strength problems involved locally in ships themselves, and therefore particularly within the province of naval architecture, but these are, after all, secondary when compared with the problem of the strength of the main structure.

STABILITY

Turning now to stability, which is the measure of the ability of a ship to remain upright or to return to the upright when inclined by an external force usually impressed by varying conditions of water surface, we find that the full and exact treatment of this branch is of quite modern origin. In the earliest day adequate stability was largely dependent on carrying ballast, and the amount and location of such ballast was determined by trial. In other words, except by following more or less closely the model of a previous vessel, there was no means of determining in advance whether a proposed design would result in a satisfactory stability condition.

About the middle of the eighteenth century the French mathematician Bouguer made a long step in developing the science of stability by developing the concept of the metacenter. In mathematical language, the metacenter is the center of curvature of the locus of the center of buoyancy of the vessel as it is inclined. As a practical proposition, the metacenter is the limit above which we cannot locate the center of gravity of the ship without having her initially unstable and unable to remain upright. The position in space of this imaginary point depends upon the geometrical form and the dimensions of the ship. Perhaps a homely illustration may clarify the matter. If you take an ordinary rocking chair and attach a weight to it in such a manner that the center of gravity of the chair and the weight is above the center of curvature of the rocker, the chair will not stay put and will loll and capsize. If the center of gravity is materially below the center of curvature of the rocker, which is the case when one sits in an ordinary rocking chair, the chair will remain in a fixed position; if the rocker is very flat, resulting in a greater distance of the center of gravity below the center of curvature, the chair will be stiff and harder to rock or heel from the upright position. The metacenter of a ship corresponds very closely with the center of curvature of the rocker, as already described.

After Bouguer developed the conception and mathematical methods for calculating the position of the metacenter, Atwood carried the matter further by calculating the righting arm or lever, which, multiplied by the weight involved, measures the torque when a vessel is inclined. The metacentric conception applies only to initial stability with the vessel upright, and for many years appears to have been sufficient, particularly as applied to sailing ships, which are very much of the same general type, with comparatively small variations of general form, relative freeboard, etc.

Something more than fifty years ago, however, the loss of the *Captain* brought home very strongly to naval architects, particularly in England, the fact that there was another factor involved in stability. A distinguished English officer, Captain Cowper Coles, took up with enthusiasm the monitor idea, first developed by Ericsson in this country, and as a result of his campaign there was built in England a low freeboard vessel called the *Captain*, with turrets and also full sail power. Naval architects of the English Admiralty were not enthusiastic over the type. The vessel had much less metacentric height than the pure monitor type, but early reports and experience with her indicated that she would be a great success, until on the night of September 7, 1870, in the Bay of Biscay, with a moderate gale blowing, she capsized, with a loss of 481 lives, including Captain Coles himself. The vessel was perfectly safe until conditions were such that she heeled over enough to bring her deck edge well under water.

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After that her righting force rapidly decreased, and at a comparatively small heel became negative, resulting in capsizing. Under the weather conditions existing the force of the wind against the sails of the *Captain* was sufficient to heel her beyond the safety angle, and over she went.

The investigation into this disastrous occurrence brought out the fact that a vessel with a comparatively small metacentric height may be perfectly safe if it retains a righting tendency at a large angle of inclination—a feature associated primarily with high freeboard. On the other hand, a low freeboard vessel, with a comparatively short range of stability, may also be perfectly safe if its mentacentric height and initial stability are very great, so that a large amount of work has to be done to incline the vessel throughout its comparatively short range of stability.

This whole question is now fairly well understood, and the naval architect is enabled to adjust his metacentric height as he will by varying proportions and dimensions of the ship to suit the position of the center of gravity and type of vessel—all requiring very careful and detailed calculations. As a matter of fact, there are passenger vessels crossing the Atlantic in perfect safety with no initial stability, or even with a slightly negative metacentric height, their freeboard and shape giving them a range of stability of as much as 90 degrees.

Resistance and Propulsion

Since the days of Fulton's first steamboat, the design of vessels' hulls, on such lines as to give the minimum resistance in passage through the water at varying speeds, consistent with the other characteristics of the ship, has become increasingly important. This is well illustrated in the case of the new battle cruisers, to which I have already referred to. To arrive at the most advantageous dimensions and form of hull, for purposes of the high speed desired, there were made and tested in the Model Tank at Washington upwards of twenty models, with the result that the resistance of the model finally adopted was nearly 15 percent less than that of the first model tried.

I would particularly invite attention to the fact, however, that this was by no means due to improvement in shape of lines alone, but also to other changes which were adopted with some reluctance, but which it was known in advance would materially reduce the resistance. Experience in recent years has fully confirmed the conclusion drawn from Model Basin investigations that, for high-speed vessels, the length is a primary factor. In fact, we know in the majority of cases of high-speed vessels that we could reduce resistance by increasing the length. This usually involves, however, increased weight of hull and other objections. So that for large, fast vessels the naval architect usually adopts dimensions which do not give the minimum resistance for the displacement, but the best all-around result, considering the total weight, including both hull and machinery.

Men-of-war in particular are generally made relatively shorter than merchant vessels, for the reason that ordinarily they travel at a low speed, and the long vessel requires more power at low speed than the short vessel, and hence on a given endurance requires a greater weight of fuel. The merchant vessel, particularly the fast passenger vessel making its passages at top speed or thereabouts, must be economical at that speed.

A hundred years ago the ideas of ship resistance were entirely crude, the usual opinion being that the resistance was in proportion to the area of the cross-section of the vessel which had to be forced through the water. About the middle of the last century Rankine put forward a theory which went to the opposite extreme. His proposition was that in a well-formed vessel the resistance was entirely due to the friction of the surface against the water, and he developed a method for estimating this. Our modern ideas on this subject are due primarily to William Froude, the originator of modern experiments, which have been the most useful appliance of research in this line one could imagine. The "law of comparison," by which, from the resistance of a small model at low speed, we can closely estimate the resistance of a large ship at high speed, is commonly called by naval architects "Froude's Law." It appears to have been originated independently by Mr. Froude, although, as a matter of fact, it is a particular case of the general law of mechanical similitude, apparently first enunciated by Newton.

Froude's Law

The resistance of ships by the Froude methods is regarded as made up of three elements: The friction of the surface, which, for low-speed vessels, may be as much as 90 percent of the total, and seldom falls below 50 percent, even for very fast vessels; the wave-making resistance, due to the energy required to create and maintain a system of waves accompanying the motion of the ship through the water; and the eddy resistance, due mainly to eddies behind stern-posts, struts and other appendages, and hence quite a small factor in the total. The "law of comparison" applies with great accuracy to the wave-making resistance, and with reasonable accuracy to eddy resistance. To frictional resistance it is not applicable, but Mr. Froude, by experiments on surfaces, established coefficients of frictional resistance which are used to this day, although for some time naval architects have felt that it would be desirable to revise these coefficients upon the basis of experiments on a large scale. The procedure we use at the present time in obtaining the lines for a ship is about as follows:

By the use of tables and curves which have been produced as the result of years of experiment at the Washington Model Basin, certain coefficients, representing a form of underwater body, are selected, as giving a close approximation to the best solution of the particular problem in hand. By the use of these coefficients we can arrive at approximation to the best dimensions for any particular ship, and by the further use of certain standard forms of waterlines can draw, with little difficulty, the lines of the vessel. From the same data we can obtain a close approximation to the resistance, at varying speeds, of a hull built from these lines. These steps permit of settling the broad general characteristics of the design. The lines so drawn are then sent to the Model Basin, where a model to exact scale is built and its resistance accurately measured at varying speeds. In important designs, as in the case of the battle cruiser, this model will receive many variations in shape and refinements of details until it appears probable that the minimum resistance for such a hull has been reached. The resistance curve obtained from the final model is then used as the basis of the design of the machinery plant and propellers for the vessel.

There are, of course, many other divisions and subdivisions of naval architecture which enable us to foretell with a considerable degree of accuracy the behavior of a vessel under the many different conditions which may be met in a varied career of service, as, for instance, the degree of punishment which a ship can stand before sinking, when subjected to attack by gunfire, submarine torpedo, and mine and aerial bomb. These are factors which

(*Concluded on page* 495.)

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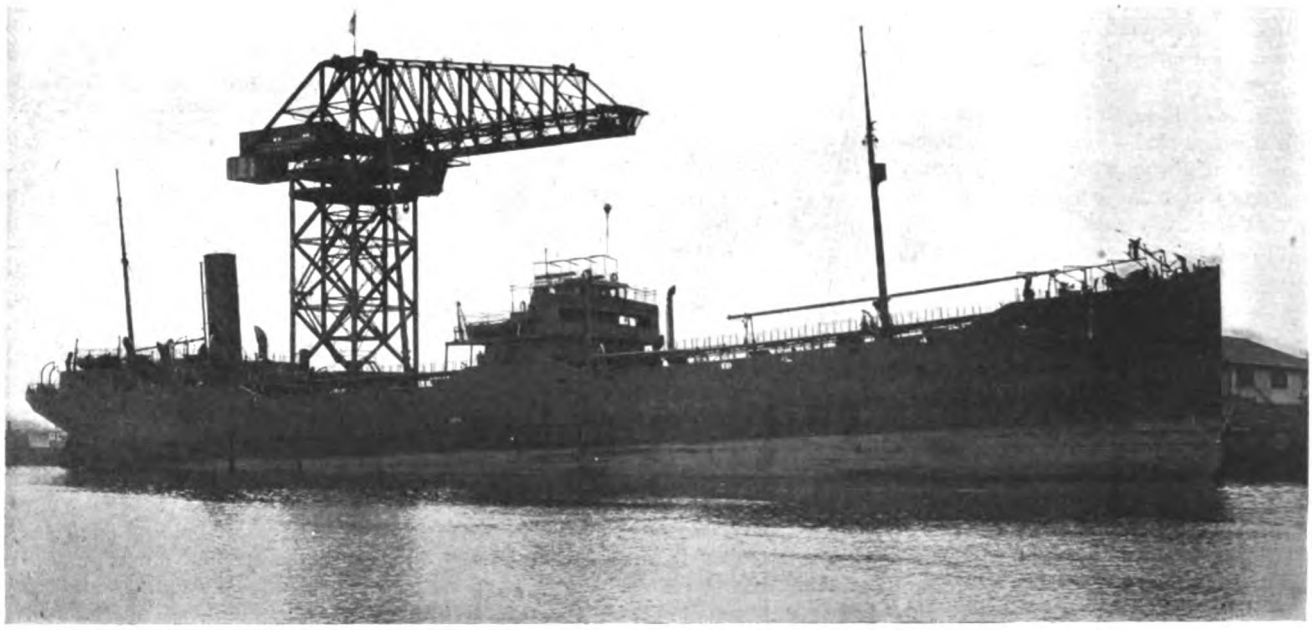

Fig. 1.—S. S. *Benjamin Brewster* at the Builder's Fitting-Out Dock

Standard Oil Tanker Benjamin Brewster

Built and Engined by Harlan & Hollingsworth Corporation, Wilmington, Del., for the Standard Oil Company of New Jersey

ON February 20, the first of four large tankers which the Harlan & Hollingsworth Corporation, of Wilmington, Del., contracted to build for the Standard Oil Company of New Jersey for carrying petroleum in bulk was launched and christened *Benjamin Brewster*. This vessel has since been completed as well as a sister ship, the *W. H. Tilford*, while two other sister ships are under construction at the Harlan & Hollingsworth yards for the same owners, and also a similar vessel for the Vacuum Oil Company of New York.

The principal dimensions of the *Benjamin Brewster* are identical with those of the *Silver Shell, Gold Shell* and *Pearl Shell* recently built by the Harlan & Hollingsworth Corporation. They are as follows:

Length overall	427 feet
Length between perpendiculars	412 feet
Beam, molded	53 feet 1 inch
Beam, extreme	53 feet 5 inches
Depth, molded to second deck	24 feet
Depth, molded to upper deck	31 feet
Load draft	24 feet 8 inches
Deadweight carrying capacity	8,130 tons
Gross tonnage	5,579
Net tonnage	3,379
Speed	11 knots

The vessel has a straight stem and semi-elliptical stern with a long poop and short bridge and forecastle. She is schooner rigged with three pole masts. Propulsion is by a single screw with the machinery aft. The officers' accommodations are in houses on top of the bridge and poop, while the petty officers' and crew's quarters are in the poop and forecastle. The general arrangement of the vessel is shown on the plans, Fig. 2, Plate I, and the main scantlings of the hull on the midship section, Fig. 4.

Hull Construction

The internal subdivision of the vessel is different from that of the "Shell" boats, as the *Benjamin Brewster* has four cofferdams, while the "Shell" boats had only two. In all there are 18 transverse and 1 longitudinal bulkheads, dividing the hull into 18 main oil tanks and 10 Summer tanks. The pump room is located amidships and a cofferdam is fitted at either end of the oil cargo space. There is also an intermediate cofferdam and an additional cofferdam between the boiler room and the fuel oil bunker, making four cofferdams in all.

Under the forward dry cargo hold a tank is fitted for ballast or for fuel oil, if fuel oil is used in the boilers. The cross bunkers are also built oil-tight so that they may be used for fuel oil. Under the engine and boiler rooms a double bottom is fitted. The hull is built on the Isherwood system of longitudinal framing.

On an extreme draft of 24 feet 8 inches the vessel will carry 8,130 tons deadweight, the gross measurement tonnage being 5,579 tons and the net tonnage 3,379 tons. The capacity plan and deadweight scale is shown in Fig. 3, Plate II.

Machinery

The cargo is handled by two large horizontal duplex cargo oil pumps with cylinders 15 and 11 inches diameter by 18 inches stroke, supplied by the National Transit Company. All necessary piping for handling oil or gasoline (petrol) cargo is fitted, together with heating piping, gas piping, vapor piping, etc. The vessel is fitted with an electric lighting plant located in the engine room and also an auxiliary electric generator located on the upper deck.

Designed for a sea speed of 11 knots, the vessel is propelled by a single screw driven by a triple expansion reciprocating engine with cylinders 27, 45 and 74 inches diameter by 48 inches stroke supplied with steam at 180

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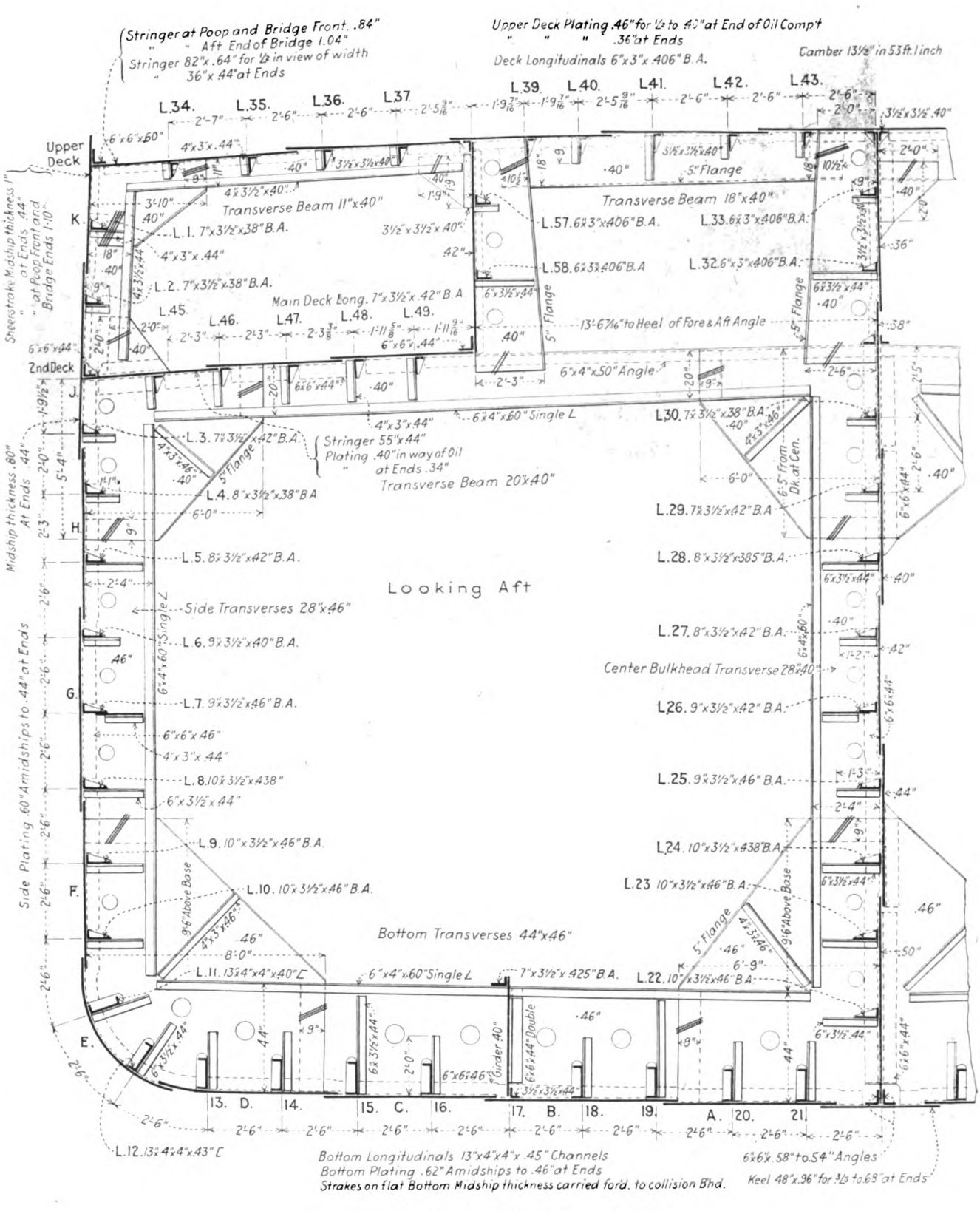
Stringer at Poop and Bridge Front .84"
" Aft End of Bridge 1.04"
Stringer 82"x.64" for ½ in view of width
" 36"x.44" at Ends
Upper Deck Plating .46" for ½ to 40' at End of Oil Compt
" " " .36" at Ends
Deck Longitudinals 6"x3"x.406" B.A.
Camber 13½" in 53ft. 1 inch
L.34. L.35. L.36. L.37. L.39. L.40. L.41. L.42. L.43.
Upper Deck
2nd Deck
Transverse Beam 11"x40"
Transverse Beam 18"x40"
Main Deck Long. 7"x3½"x.42" B.A.
13'-6 7/16" to Heel of Fore & Aft Angle
6"x4"x.50" Angle
6"x4"x60" Single L
Stringer 55"x44"
Plating .40" in way of Oil
" at Ends .34"
Transverse Beam 20"x40"
Looking Aft
Side Transverses 28"x46"
Center Bulkhead Transverse 28"x40"
Bottom Transverses 44"x46"
6"x4"x60" Single L
7"x3½"x.425" B.A.
Bottom Longitudinals 13"x4"x4"x.45" Channels
Bottom Plating .62" Amidships to .46" at Ends
Strakes on flat Bottom Midship thickness carried forward to collision Bhd.
6"x6"x.58" to .54" Angles
Keel 48"x.96" for 3/8 to .69" at Ends
Sheerstrake Midship thickness 1" at Ends .44" at Poop Front and Bridge Ends 1.10"
Midship thickness .80" At Ends .44"
Side Plating 60" Amidships to .44" at Ends

Fig. 4.—Midship Section, S. S. *Benjamin Brewster*

pounds per square inch working pressure from three marine type Scotch boilers, each 15 feet 6 inches diameter by 11 feet 7 inches long. The boilers have a total heating surface of 8,300 square feet and are arranged for burning oil or coal as fuel, under the Howden system of hot air forced draft.

The vessel is equipped with wireless apparatus, fire-fighting, life-saving, signaling and navigating appliances, as required by the United States Steamboat Inspection Service. The officers' and crew's accommodations are very commodious and well appointed, fully equipped to pass the United States Steamboat Inspection requirements.

The hull and machinery throughout is built to the highest class at Lloyd's under special survey by Mr. J. S. But-

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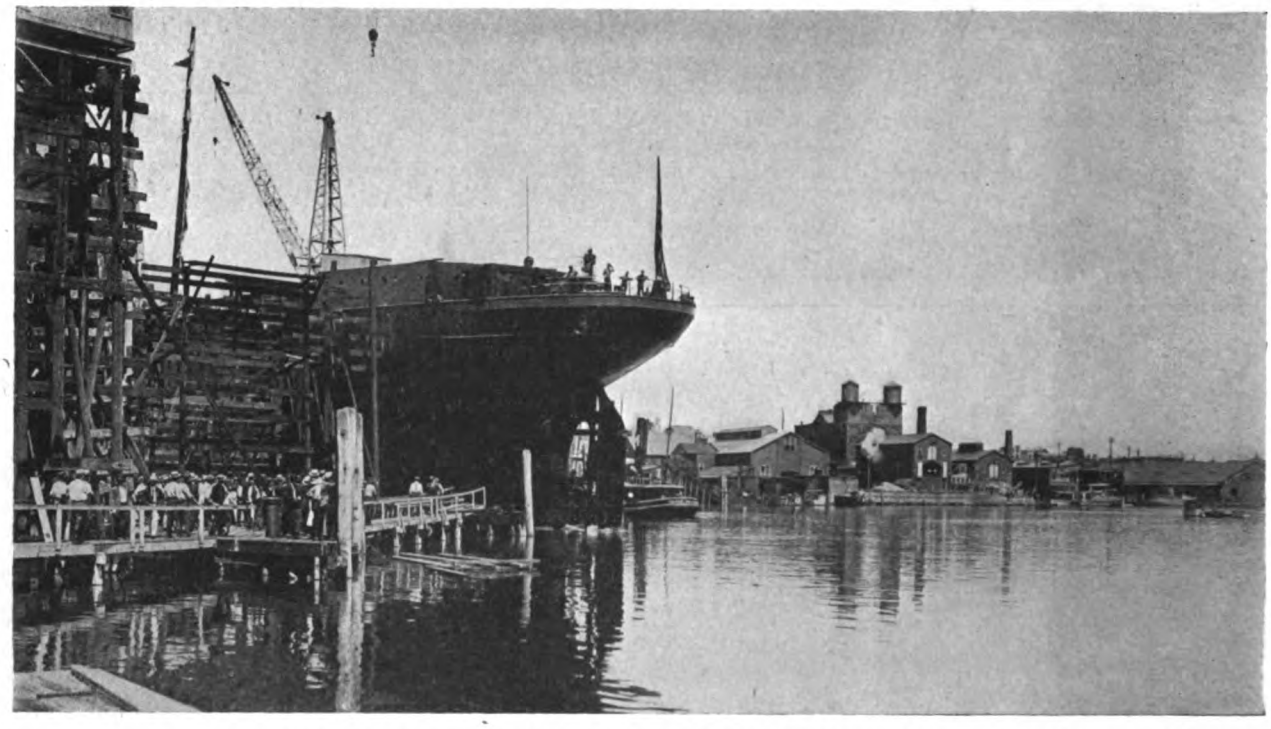

Fig. 5.—Launching of S. S. *Benjamin Brewster* at Yards of Harlan & Hollingsworth Corporation, Wilmington, Del., on February 20

ler and Mr. J. Blellock, Lloyd's surveyors. For the above particulars and plans of the vessel we are indebted to Mr. R. W. Bruce, naval architect, of the Harlan & Hollingsworth Corporation.

Regulations for the Protection of Ships in Danger Zones

The United States Shipping Board has issued a set of rules, based upon a consideration of the facts relating to the sinking by mines or submarines of a large number of vessels, which are recommended for adoption by the owners and masters of ships in service in danger zones. Copies of these rules will be furnished free of charge by the Shipping Board.

Experience has shown that vessels holed by mines or torpedoes sink so rapidly as not to permit the taking of corrective measures. Open watertight doors, side scuttles and other apertures in hulls have caused the loss of ships which otherwise, perhaps, might have been kept afloat. Lives have been lost as a result of the failure in anticipation of disaster to provide for an expeditious transfer to boats and rafts of passengers, officers and crews.

Every precaution, therefore, should be taken in advance of entering a danger zone to minimize the risk of mines and submarines, and the promulgation by owners and masters of the regulations suggested by the Shipping Board, it is believed, will contribute materially to that end.

The printed regulations cover only twelve pages of a pocket-size pamphlet, and, therefore, can be quickly and easily assimilated. They refer specifically to the maintaining in efficient condition at all times of watertight bulkheads, tunnels and doors, the closing of openings in ships' sides, care of bilge pumps, stowing of cargoes, emergency lighting of ships, berthing of passengers, means of reducing the visibility of vessels and the handling of lifeboats and other life-saving appliances.

It is of first importance, of course, that doors in watertight bulkheads should be constantly inspected and kept in perfect working order. Watertight doors should be leaving stokeholds by means of the fiddley ladders. Where opened at sea only when absolutely necessary. The watertight doors in passageways from firemen's quarters to stokeholds should be kept closed, the firemen entering and practicable, it is recommended that watertight trunks should be fitted from bulkhead decks to shaft tunnels, and tunnel doors should be kept closed. If there are side bunkers, or bunkers the doors to which are in non-watertight bulkheads, coal should be worked from such bunkers while in danger zones and doors to watertight bulkheads should be kept closed.

With the exception of ash chutes and similar apertures required to be opened at sea, side scuttles and other openings in ships' sides below the uppermost continuous deck and in the first tier of erections above that deck should be kept closed while the vessel is in a danger zone.

Bilge pumping installations should be maintained at all times in an efficient condition. Before the commencement of each voyage bilges and strum boxes in holds and machinery compartments should be cleaned and defects in the system should be corrected. If practicable an additional screw-down non-return valve should be fitted in each pipe line on the watertight bulkheads inside compartments in which strum boxes are located and valves should be secured by studs screwed into bulkheads.

The fate of the men below decks in the recent *Antilles* disaster eloquently emphasizes the importance of the recommendations as to the berthing of passengers, which provide, that while traversing a danger zone passengers should be berthed above the uppermost continuous deck and watertight doors and scuttles in passengers' quarters below that deck, as well as sanitary discharges connected with such quarters, should be kept closed.

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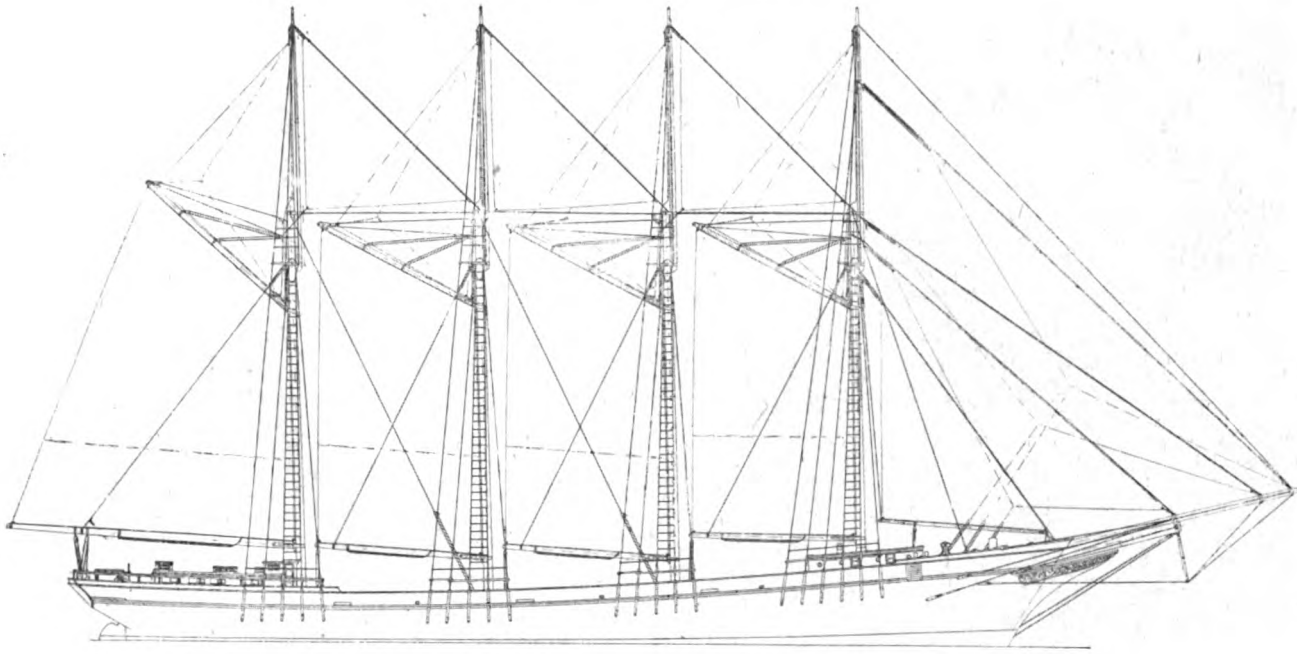

Fig. 1.—Sail Plan of Four-Masted Anxiliary Wooden Schooner Building in New Brunswick

Auxiliary Schooners Building in New Brunswick

TWO 185-foot auxiliary four-masted schooners are now building by D. H. Saker & Co., St. John, N. B., from designs by J. Murray Watts, naval architect, Philadelphia, Pa. The first of these boats is in frame, and the keel of a duplicate will shortly be laid. The general dimensions are: Length over all, 185 feet; length on keel, 160 feet; beam extreme, 40 feet; depth of hold, 14 feet; molded depth, 15 feet 8 inches.

The vessels are constructed to the latest requirements of Lloyds and the American Bureau of Shipping, and utilize as far as possibe the timber available in New Brunswick. The keel is of birch 14 inches by 20 inches, with a 4-inch birch shoe. The timbers are birch below the waterline and black spruce above, sided 11 inches double, molded 14 inches and spaced 27 inches. The keelson consists of three tiers of 14-inch by 14-inch British Columbia fir, and the sister keelsons of two tiers on each side of 14-inch by 14-inch British Columbia fir. The deck beams are also 14-inch by 14-inch British Columbia fir, spaced 3 feet 6 inches apart.

The planking varies from 7 inches to 4 inches in thickness; the under-water portion being birch and the topsides being 4½-inch black spruce. The decking is of 3½-inch spruce. Practically all the deck joiner work, houses and hatches will also be of spruce. The masts, however, will be of Oregon pine, the foremast being 25 inches in diameter and the other three masts 24 inches in diameter; all 84 feet in length. The topmasts are 48 feet 6 inches long and will be of spruce, as will be the other spars, with the exception of bowsprit, jib boom and spanker boom, which will be of Oregon pine.

The engine for one of the boats will be a 250-horsepower Kahlenberg oil engine, while the engine for the second schooner has not yet been decided on.

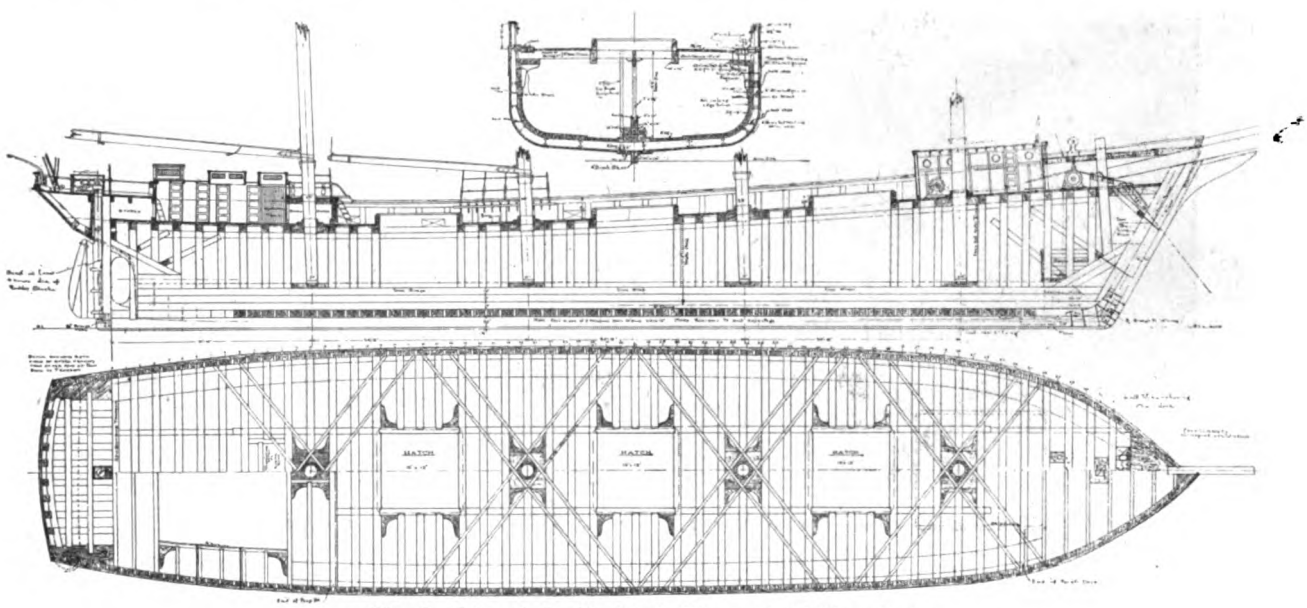

Fig. 2.—Inboard Profile, Deck Plan and Midship Section

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GIANT CRANE FOR UNITED STATES NAVY YARD

Built by Wellman-Seaver-Morgan Company, Cleveland, Ohio

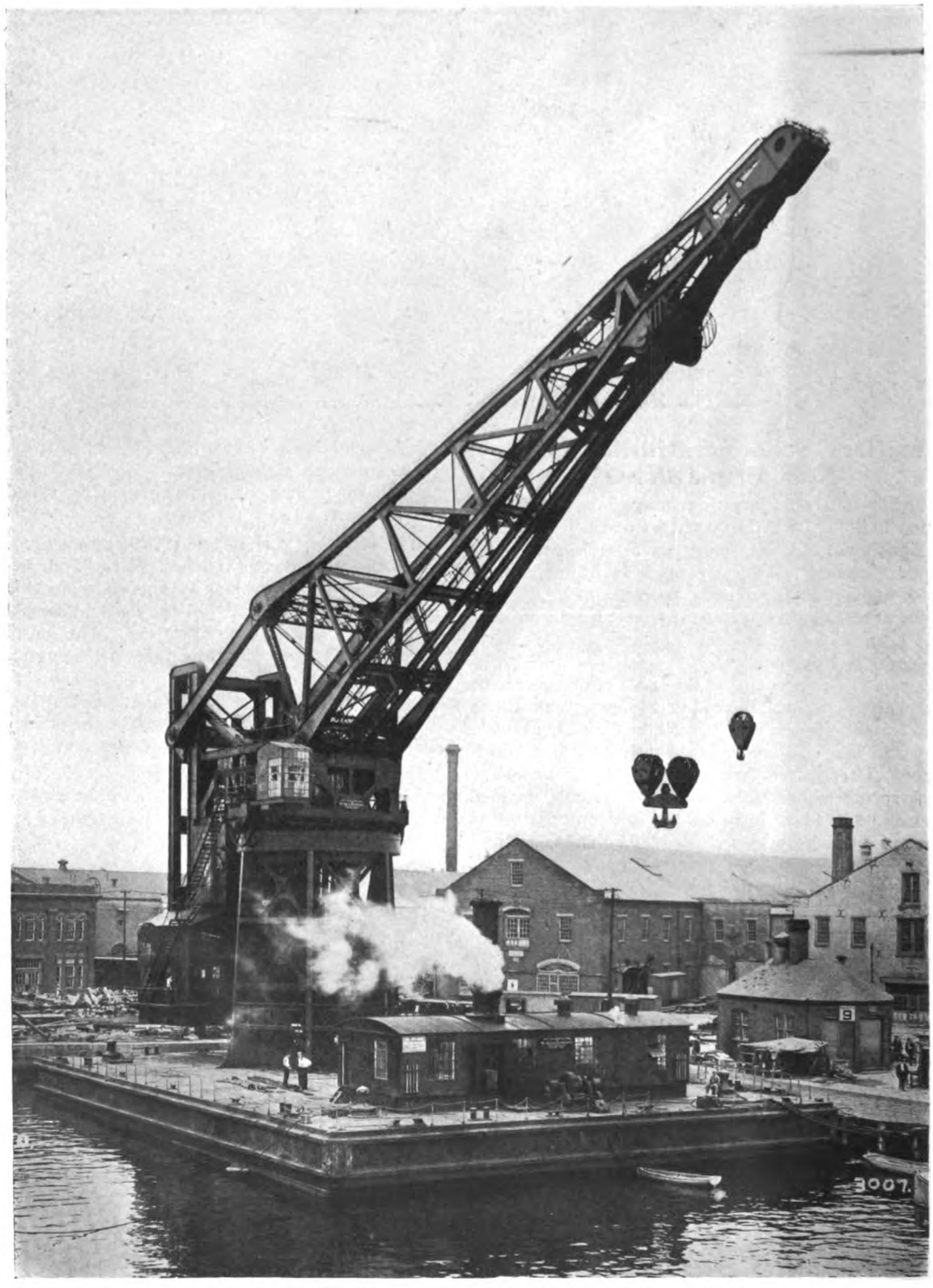

Fig. 1.—Crane Completed and Ready for Test at Norfolk Navy Yard

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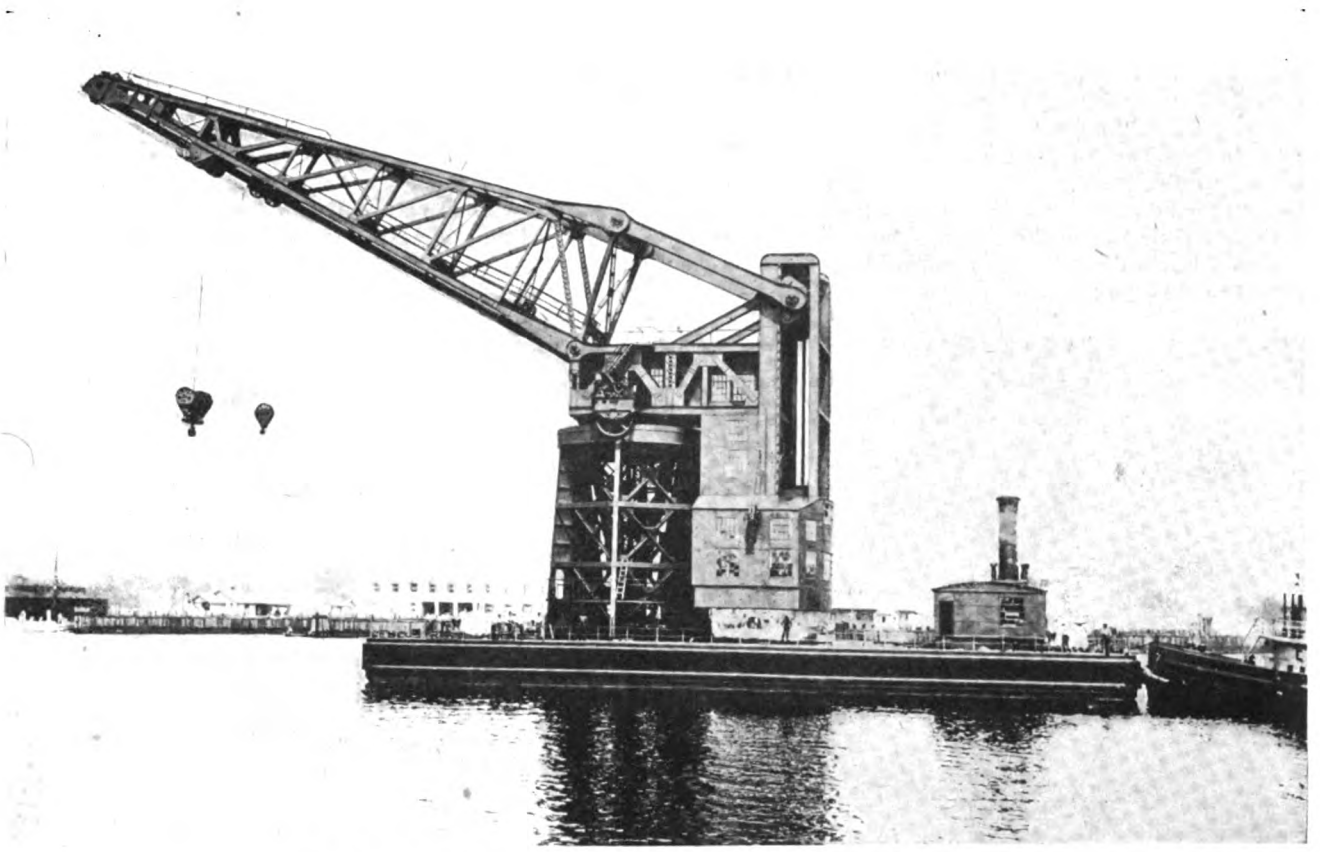

Fig. 2.—Broadside View of Crane, Tower and Pontoon with Power Plant

Giant Crane for United States Navy

Two Hundred-Ton Floating Crane Built by Wellman-Seaver-Morgan Company, Cleveland, for Norfolk Navy Yard

THE largest floating crane ever constructed in the United States has recently been designed and built by the Wellman-Seaver-Morgan Company, Cleveland, Ohio, for the United States Navy. It is now being used by the Navy Department at the Norfolk Navy Yard.

This crane is mounted on a pontoon 140 feet long, 85 feet wide and 15 feet deep. It has a lifting capacity of over 200 tons. The test load required by the Navy for this machine, which it has already successfully handled, was 403,200 pounds, at a reach of 62 feet 6 inches over the side of the boat, or at a radius of 105 feet.

The builders of this crane have in the past few years successfully entered a field formerly monopolized by two or three European firms. This firm has also built three other large floating cranes for the Navy, but none as large as this. The previously built cranes have been of the bridge type, in which the whole crane with its pontoon are turned and maneuvered to bring the hoisting cables to the proper positions for lifting loads.

The machine just completed, however, resembles somewhat in principle the ordinary revolving derrick, in which the jib is rotated until it comes opposite the work to be lifted and is then lowered until the hooks hang above the object to be lifted. The hooks are then lowered or raised by means of steel cables passing over sheaves built into the end of the jib.

To give a more concrete idea of the size and capacity of this apparatus, it may be said that its full-load capacity is equivalent to the weight of 100 of the largest touring cars. The crane would readily lift an ordinary shifting locomotive. The main hoist consists of two hooks, weighing 75 tons each, fixed on the jib. When raised to its maximum height the top of the jib is over 200 feet above the water level; a height greater than that of an 18-story building. It must also be remembered that the whole structure is mounted on a floating pontoon, the stability of which must not be endangered by handling these immense loads. The total displacement of the pontoon crane is 5,000,000 pounds.

The pontoon itself contains a complete boiler plant and 150 kilowatt, engine-driven generator, which supplies the electric current for operating the various motions of the crane, which are controlled from a small house mounted high above the deck. One operator, by means of a few levers and master controllers (similar to those used in a passenger elevator), is able to control all the functions with the utmost delicacy.

The electrical mechanism is such that when the heavy loads are lowered the motors are turned into generators in such a way that the speed can be controlled with great nicety. In case of an accidental interruption of electric current, all motions of the crane are automatically locked by means of magnetic brakes, so that it is impossible to drop the load from such a cause. Great safety and accu-

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racy of control are essential, as the crane is used to handle large guns and turrets on battleships. These must not be damaged, their value being hundreds of thousands of dollars.

Fig. 3 shows the first work which this crane was called upon to do. The Navy tug *Massasoit* was suddenly sunk in one of the harbors. After divers had passed cables under the tug, they were attached to the crane and the tug was readily and quickly lifted to the surface, as shown.

It will be recalled that the Panama Canal Commission purchased two large cranes of this type for heavy lifting

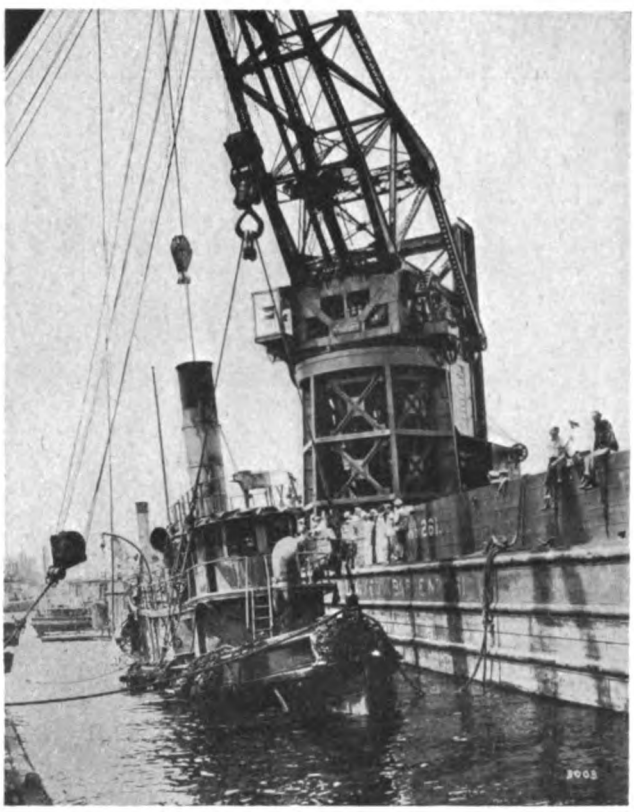

Fig. 3.—Floating Crane Hoisting Sunken Tug

work at Panama. These cranes were bought from a large German corporation. When the test load was applied (which was the same as was applied to the machine shown in the illustration) the first of these German-built cranes collapsed and was wrecked, owing to the faulty design of the structure. In comparison, no weaknesses whatever have developed in any of the floating cranes built by the Cleveland concern.

The crane rotates in a complete circle, the rotating being controlled by two 60 horsepower motors. The boom luffs up and down from a practically vertical position to an angle of about 30 degrees in the horizontal, in its lowest position. The luffing is accomplished by two 10-inch screws operated by two 60 horsepower motors.

The two main hoists can operate separately or simultaneously, as desired. When lifting the maximum load it is operated by two 60 horsepower motors. An auxiliary hoist of 25 tons capacity, movable up and down the boom, has a separate motor for hoisting and trolleying, each of which is 60 horsepower.

The counterbalance at the aft end of the crane is fixed and amounts to 600,000 pounds.

The crane is provided with four electrically-driven capstans, one at each corner of pontoon. There are also two steam-driven anchor hoists, one at each end.

The main pivotal bearing, or step bearing, supports a ball or universal joint and carries a maximum load of 2,021,000 pounds.

The speed of the main hoist under maximum load is about 6 feet per minute. The speed of the auxiliary hoist is 30 feet per minute. The speed of rotation is one revolution in four minutes. The boom is luffed from one to the other extreme position in twelve minutes. During the test all the speeds of this crane were in excess of those required by the specifications. The side lists and end lists were both under specified limits, the maximum side lists having been specified at 6 degrees.

The design was carefully worked out and it has not been found necessary to make any changes in a second machine now being built. About 5,000 tons of steel were required to build the superstructure including the crane and its tower.

Programme of Annual Meeting of Society of Naval Architects and Marine Engineers

The twenty-fifth general meeting of The Society of Naval Architects and Marine Engineers will be held in Assembly Room No. 1, Engineering Societies Building, 29 West Thirty-ninth street, New York City, Thursday and Friday, November 15 and 16, 1917, and will begin at 10 A. M. each day. The society's office will be open for the use of all members, and the usual conveniences provided.

There will be a banquet in the Grand Ball Room of the Waldorf-Astoria at 7 P. M., Friday, November 16, to which all members and their guests are cordially invited.

The Council will meet at 3 P. M., Wednesday, November 14, in the Council Room, Engineering Societies Building. Applications for membership should be mailed so as to reach the secretary on or before November 14.

The preliminary program of papers to be read at the meetings is as follows:

THURSDAY, NOVEMBER 15

1. "Safety of Life and Property at Sea, with Studies Relative to the Possibility of Rendering Ships and Merchandise Unsinkable." By William T. Donnelly.

2. "Shipbuilding in the Gulf States and the Natural Resources and Facilities Favorable Thereto." By Charles N. Crowell.

3. "Progress of Marine Engineering and the Education of the Marine Engineer." By Robert Haig.

4. "Wind and Fouling Resistance on the *Neptune*." By W. W. Smith.

5. "Cargo Ship Lines of Simple Form." By Naval Constructor Wm. McEntee, U. S. N.

6. "Recent Developments in Tank Steamer Construction." By Robert W. Morrell.

7. "Power and Economy Tests of the S. S. *Pontiac*." By A. G. Mattsson and Thomas Durkin.

FRIDAY, NOVEMBER 16

8. "Labor and Patriotism." By Asst. Naval Constructor A. W. Carmichael, U. S. N.

9. "Application of Electricity to Various Auxiliaries on Shipboard." By H. L. Hibbard.

10. "Submarine Hulls—Comments on Various Types." By Naval Constructor E. S. Land, U. S. N.

11. "The Influence of the War on Submarine Policy." By Marley F. Hay.

12. "An Analysis of the Principles of Industrial Management." By Naval Constructor T. G. Roberts, U. S. N.

13. "Fabricated Ships." By R. H. M. Robinson.

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The Trend in Marine Engineering*

Turbine Development and Adoption of Speed Reduction Gearing—Progress of Watertube Boilers and Superheaters

BY C. R. BRUCE

TAKING the period up to the declaration of war, the quadruple expansion engine had to a very considerable extent superseded the triple expansion type for ships intended to make long voyages, and more especially for passenger liners in which a four crank engine had to be fitted on account of high power and greater smoothness of running. For cargo steamers, even of large size, however, the majority of owners still pinned their faith to the three cylinder engine, the argument being that any gain in fuel economy due to the quadruple principle was neutralized by the loss of cargo space, and increased first cost, weight and upkeep.

It is further to be observed that when superheaters are fitted, triple expansion engines are as economical as quadruple engines with saturated steam. The practice of superheat has greatly extended in recent years. At the present time there are about 1,000 merchant vessels, representing close on 2,000,000 horsepower, fitted with superheaters of the smoke-tube type. Independently oil-fired superheaters have been suggested as an alternative, and there are two owners at least who are giving the question serious consideration for vessels now under construction on the Clyde.

Direct-Acting Turbines

Turning to the faster vessels associated with the passenger service, the reciprocating engine appears in a new light. It was in the cross-channel passenger service that the inherent limitations of the reciprocating engine first became apparent. In the later nineties, with the higher powers of cross-channel steamers and the lightness demanded, a point was reached beyond which further development of the reciprocating engine could not be hoped for. In the meantime a significant departure was made in the Navy, when the destroyers *Viper* and *Cobra* were ordered in 1898 and fitted with Parsons turbines. The promising performances of these pioneers led in 1901 to the building of the turbine steamer *King Edward*, which was followed by the cross-channel steamer *Queen* in 1902, and the *Brighton* in 1903; and it is common knowledge that the success of these vessels led to the wholesale adoption of the steam turbine for cross-channel service. Thus the introduction of the steam turbine proved opportune by opening up a way to further progress in economy, combined with lightness, far beyond the possibilities of the reciprocating engine.

The turbine was now fairly established in the cross-channel service, but the reciprocating engine was still supreme in the field of the large liner. It was not until 1905 that the turbine entered the lists in the transatlantic service, when the *Victorian* and *Virginian* of the Allan Line took up their stations, to be followed later in the same year by the Cunard liner *Carmania*. The results on service of this latter vessel did not warrant the adoption of direct acting turbines to drive a ship of this type at a speed of 18 knots, for it was found that the coal consumption of the *Carmania* was considerably greater than that of her sister ship, the *Caronia*, with quadruple expansion engines. The performances of the *Carmania* did not, however, interfere with the employment of turbines for liners of relatively high speeds, and direct acting turbines were fitted from this time onwards to many first class liners, such as the *Lusitania*, *Mauretania*, *Aquitania*, *Imperator*, *Alsatian*, *Calgarian*, etc.

The Combination System

The higher consumption of the *Carmania* as compared with that of the sister ship was a setback to the direct turbine for moderate speeds. This bid fair to interfere with the natural development of the intermediate liner, for which greater powers were being demanded day by day. In 1901, however, an interesting experiment had been tried in the destroyer *Velox*, which was fitted for cruising speeds with a combination system of machinery in which the reciprocating engines exhausted into ordinary Parsons low pressure turbines, showing by this means a notable reduction in steam consumption.

In 1908 the "combination system," as this arrangement came to be termed, was tried in the *Otaki* for the main engines. In comparison with the *Orari* and *Opawa*, which were sister ships having triple expansion engines, the *Otaki* gave an economy in steam consumption of about 20 percent. The arrangement, however, was essentially one to be associated with vessels of relatively high power and the largest dimensions, and the comparative popularity of the combination system may be gathered from the statement that, taking ocean liners of over 3,000 tons register, there are some 28 driven by direct turbines and 24 by combination machinery.

While the combination arrangement of machinery undoubtedly supplied a notable link in the development of marine propulsion, it could not be looked upon at best as anything but a makeshift, and when the combination system seemed most firmly established ingenious minds were at work with the object of eliminating the weak partner—that is, the reciprocating element. Investigation proved that the turbines of the *Carmania* ran too slowly and the propellers too fast, and it became obvious that a link would require to be introduced which would enable a maximum overall propulsive efficiency to be obtained. Various expedients were proposed with this object in view, of which mechanical gearing is the simplest and most widely adopted.

Turbines and Mechanical Gearing

The application of Parsons turbines and mechanical gearing in the single screw steamer *Vespasian* in 1910 is a matter of history. In 1911 the cross-channel steamers *Normannia* and *Hantonia* were fitted with mechanical gearing, to be followed in 1913 by the *Paris* and *King Orry*.

For ocean-going steamers, however, owners still fought shy of the new arrangement, and it said much for the foresight and enterprise of the Cunard Company that they decided in 1913 to adopt geared turbines for their twin screw steamer *Transylvania*, which was then in course of construction at Greenock. This vessel was the first ocean-going liner to be so fitted. The *Transylvania* had single reduction gear, in which the reduction of propeller revolutions was obtained in a single stage. When turbines

* From a paper presented before the Greenock Association of Engineers and Shipbuilders.

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TABLE I.—PROGRESS IN MARINE MACHINERY, CARGO STEAMERS.

Year when built.	1877.	1885.	1911.	1914.	1916.
Ship Dimensions:					
Length and Beam	314′ x 35′	320′ x 38′	440′ x 52′6″	450′ x 56′	503′ x 63′
Performance:					
Speed in knots	11.25	12.25	13.25	14.25	14.25
Horsepower	775 I.H.P.	1,650 I.H.P.	4,200 I.H.P.	6,000 S.H.P.	7,000 S.H.P.
Engines:					
No. of Propellers	One.	One.	One.	One.	Two.
Type of Machinery	Tandem compound with fly wheel.	Triple-expansion.	Triple-expansion.	Parsons' geared turbines, single-reduction, one h.p. and one l.p.	Brown-Curtis turbines and double-reduction gear, two h.p. and two l.p.
Propeller R.P.M.	52	70	73	102	80
Piston Speed—feet per min	450	560	750	1,350 revs. of turbines.	H.p. turbines 3,500 revs.; L.p. turbines, 2,500 revs.
Referred Mean Press	23	31.5	35	....	....
Condenser Surface per Horsepower	2.17	1.83	1.50	1.18	1.12
Boilers:					
No. and type	One, oval ends and round middle portion.	Two, cylindrical, single-ended.	Two, main cylindrical, double-ended.	Two, cylindrical, double ended.	Three, cyl. oil-fired boilers (with Robinson superheaters), D.-E.
Working Pressure, square inch	70 lb.	150 lb.	190 lb.	195 lb.	200 lb.
System of Draft	Natural.	Natural.	Forced Draft.	Howden's Forced Draft.	Wallsend Howden oil-burning.
Heating Surface per Horsepower, square feet	4.46	2.82	2.80	2.30	2.25
Horsepower per square foot of grate	7.6	10.4	16.25	20.0	....
Weights:					
Total weight of machinery steam up	200 tons.	340 tons.	900 tons.	930 tons.	1,100 tons
Horsepower per ton of machinery	3.87	4.85	4.67	6.45	6.35
Fuel Consumption:					
Per horsepower	About 2.5 lb.	1.95 lb.	1.65 lb.	1.45 lb.	0.85 lb.

TABLE II.—PROGRESS IN MARINE MACHINERY, CROSS-CHANNEL STEAMERS.

Year when built.	1890.	1898.	1904.	1910.	1916.
Ship Dimensions:					
Length and Beam	300′ x 34′ 6″	315′ x 37′	330′ x 42′	316′ x 41′	302′ x 35′ 6″
Performance:					
Speed in knots	18	19.75	19.5	21.5	23.5
Horsepower	4,400 I.H.P.	5,520 I.H.P.	5,500 S.H.P.	8,500 S.H.P.	12,300 S.H.P.
Engines:					
No. of Propellers	Two.	Two.	Three.	Three.	Two.
Type of Machinery	3-cyl. Triple-expansion.	4-cyl. Triple-expansion.	Parsons' direct turbines, one h.p. and two l.p.	Parsons' direct turbines, one h.p. and two l.p.	Parsons' geared turbines, two h.p. and two l.p.
Propeller R.P.M.	130	165	550	625	435
Piston Speed—feet per min	780	910	550 revs. of turbines.	625 revs. of turbines.	H.p. turbines, 2,600; L.p. turbines, 1,800.
Referred Mean Press	30.75	43.0	....	....	....
Condenser Surface per Horsepower	1.42	1.4	1.35	0.75	0.6
Boilers:					
No. and Type	Five S.E. cyl.	Four S.E. cyl.	Two D.E. and one S.E.	Seven water-tube.	Eight Water-tube.
Working Pressure, square inch	160 lb.	180 lb.	150 lb.	190 lb.	195 lb.
System of Draft	Natural.	Forced.	Forced.	Forced.	Forced.
Heating Surface per Horsepower, square feet	2.6	1.95	1.9	1.95	2.0
Horsepower per square foot of grate	12.25	17.5	16.5	15.0	22.0
Weights:					
Total weight of machinery, steam up	590 tons.	610 tons.	590 tons.	735 tons.	1,055 tons.
Horsepower per ton of machinery	7.45	9.02	9.3	11.6	11.65
Fuel Consumption:					
Per horsepower	2.25 lb.	2.1 lb.	1.8 lb.	1.7 lb.	1.5 lb.

requiring a reduction of 5 to 9 are fitted, it will usually be found that they may be designed to run as fast as their construction will permit, and in this class are included all high-speed vessels.

With the larger reduction ratios, however, it will often be advisable and necessary to effect the reduction in two stages, by the adoption of what is known as double reduction gear. With this arrangement the pinion on each turbine drives a first reduction wheel, the spindle of which is provided with a further pinion, gearing into a second reduction wheel keyed to the propeller shaft.

The following advantages have been claimed for an arrangement of turbines and gearing on this principle:

1. Increased range of reduction.
2. The turbines are much smaller in diameter.
3. The gear wheels are considerably reduced in size, while the pinions are increased, giving a much better tooth contact.

Whether mechanical gearing will fulfill all expectations remains to be seen. According to present indications, it would seem that the advent of the geared turbine means that the reciprocating engine is doomed for powers above, say 3,000 horsepower for single screw and 6,000 horsepower for twin screw ships.

STEAM BOILERS

As regards steam generating, while the cylindrical boiler has remained almost unchanged in general design and construction during the last twenty years and more, the watertube boiler has made great progress in the same period. Among the lighter classes of naval vessels great power is demanded on the lightest possible weight, and, as might be expected, it is in this sphere that the marine watertube boiler made its first appearance in 1893 or thereabouts. In the merchant service shipowners adopted a conservative attitude towards the new boiler, though in

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TABLE III.—PROGRESS IN MARINE MACHINERY, INTERMEDIATE OCEAN LINERS.

Year when built.	1880.	1892.	1911.	1914.	1916.
Ship Dimensions:					
Length and Beam	400' x 45'	470' x 53'	520' x 64'	550' x 66 6"	550' x 66'
Performance:					
Speed in knots	12.5	12.5	14.5	16.5	17.0
Horsepower	3,000 I.H.P.	3,500 I.H.P.	7,500 I.H.P.	11,000 S.H.P.	11,000 S.H.P
Engines:					
No. of Propellers	One.	Two.	Two.	Two.	Two.
Type of Machinery	Vertical compound.	Vertical triple-expansion.	Vertical quadruple-expansion.	Parsons' geared turbines, two h.p. and two l.p., with helical gearing.	Brown-Curtis geared turbines, two h.p. and two lp., with double-reduction gear.
Propeller R. P. M.	61	80	82	133	85
Piston Speed—feet per min.	671	640	738	1,650 revs. of turbines.	H.p. turbines, 3,200; L.p. turbines, 2,000.
Referred Mean Pressure	20.5	32.0	37.0	....	....
Condenser Surface per Horsepower	1.85	1.60	0.84	0.80	0.62
Boilers:					
No. and type	Two cylindrical.	Two D.E. and one S.E. cyl.	Five D.E. cyl.	Five D.E. cyl.	Five Yarrow, burning oil.
Working Pressure, square inch	90 lb.	170 lb.	210 lb.	210 lb.	250 lb.
System of Draft	Natural.	Natural.	Natural.	Howden's F.D.	Wallsend-Howden oil-burning.
Heating Surface per Horsepower, square feet	3.1	3.3	3.25	2.5	2.25
Horsepower per square foot of grate	7.6	10.0	11.75	17.5	....
Weights:					
Total weight of machinery, steam up	685 tons.	795 tons.	1,750 tons.	1,800 tons.	1,210 tons.
Horsepower per ton of machinery	4.35	4.4	4.25	6.1	9.1
Fuel Consumption:					
Per horsepower	2.375 lb.	1.875 lb.	1.5 lb.	1.35 lb.	0.875 lb.

the succeeding years a number of comparatively small vessels abroad were fitted with Babcock & Wilcox watertube boilers. It may be stated that there is at present at least one merchant vessel under construction on the Clyde with watertube boilers of the Yarrow type.

Before long the tank boiler will be displaced by the watertube boiler in the case of high-powered vessels, and, as owners gain confidence in the new generator, it will be largely adopted for merchant ships of moderate speed. There is a growing feeling that something still better can be done in the direction of large capacity watertube boilers, with higher pressures and greater intensity of steam production. The question is of prime importance to the naval architect, and it will be interesting to watch developments in the near future.

In recent years great improvements and refinements have been made with regard to oil-fuel burning apparatus in the merchant service. The advantages of oil fuel are obvious where oil can be obtained at a reasonable price, and with the projected extension of the system of oil depots over the principal trade routes oil burning will become more general. It is significant that an increasing number of ships are being fitted to burn alternatively oil or coal, as may be the more economical.

ELECTRICAL PROPULSION

With regard to electrical propelling installations, it is interesting to note in the report of Lloyd's Register for 1916 that two vessels so equipped are being built in the United Kingdom to the society's class. Electrical propulsion is favorably reported upon in America, where it is at present being installed on certain war vessels. It is in the heavier classes of naval work that the field of electrical propulsion seems most promising, on account of interchangeability and the great range of speeds over which good economy can be maintained. In this particular respect the electrical system is superior to all other methods of marine propulsion.

In the merchant service, however, such considerations are of little importance. Still, one cannot say how far the development of the passenger liner may go, and it may be that in such vessels will be found opportunities for the application of electrical propulsion. Powers may be demanded in the future beyond the scope of the geared turbine, and the electrical system would seem to possess all the essentials for the development of the highest powers.

ENGINE-ROOM AUXILIARIES

In connection with the main engines, it has been stated that the trend of development is all towards the elimination of the reciprocating elements, and it is interesting to observe the same tendency in the case of the engine-room auxiliaries. The driving of auxiliaries on board a vessel by steam turbines or rotary steam engines presents a number of advantages. Alternative proposals have been made from time to time in the direction of driving the various engine-room auxiliaries by electric motors supplied with current from a central generating station, and the proposition has undoubtedly attractive features. The difference in weight and space occupied by auxiliaries on the rotary principle, whether steam or electric, is striking, and the merchant service cannot long remain uninfluenced by this development. Important auxiliaries to which the rotary principle has been applied are the feed pumps, the ventilating and forced draft fans, and the main circulating pumps.

Coming to the main air pumps, it is being proposed to do away with these and provide a steam jet installation to take care of the air liberated in the condenser, and a motor driven centrifugal pump to deal with the condensate from the main condenser.

In many directions there have been developments in connection with steam propelling machinery. A rational design of condenser has been evolved. More attention is being paid to the efficient lagging of hot surfaces, which represents one of the best and safest of all economies. The new applications of the steam turbine have brought in their train improvements in the design and lubrication of bearings. A noteworthy development in this direction is the increased adoption of Michell bearings, by which means the length of thrust block is reduced by more than half. Following this development, the familiar thrust recess will disappear from steamships.

THE INTERNAL COMBUSTION ENGINE

The internal combustion engine demands attention, for it is representative of the spirit of the age. The possibilities opened up by this engine are so attractive from

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the shipowner's point of view that before long it will not be surprising to find the steam engine displaced for new tonnage of relatively small power. On the other hand, from the highest powers down to, say, 3,000 shaft horsepower for a single screw, the steam turbine, geared or otherwise, holds the field to-day. Between the two there is a doubtful dividing line, where either the reciprocating steam engine or the oil engine may best serve the purpose, according to the conditions of the particular case.

In considering, however, the prospects of the general adoption of the oil engine for marine propulsion for powers within its prescribed range, it must not be overlooked that the limits of the world's production of oil will prove an important factor.

Tables I, II and III show the progress in marine machinery of (*a*) cargo steamers, (*b*) cross-channel steamers and (*c*) intermediate ocean liners.

Motor Tug with Reduction Gear

IN view of the growing importance of the oil burning motor and the ever-widening scope of its application to marine propulsion, the accompanying plans of a motor tug by the Edwards Engineering Company, of Philadelphia, are timely and of more than usual interest.

The unique feature is the reduction gear which has been introduced in order to enable the boat to compete on an equal footing with the steam tug when handling heavy tows. The average motor tug with its comparatively small propeller turning at 300 to 400 revolutions per minute cannot handle a heavy barge or other vessel with the same facility as a steam tug developing the same power at 90 to 100 revolutions per minute and turning a much larger and higher pitched wheel. A large part of the average tug's work is done at speeds of 3 to 4 miles per hour, or even less, and to get efficient application of power under these conditions the propeller should turn at not above 120 revolutions per minute as a maximum. As the revolutions are increased above this, excessive slip and cavitation result, especially when getting under way and maneuvering.

The propelling machinery shown in this plan consists of a 100-horsepower Fairbanks Morse type "C-O" oil engine driving a 54-inch propeller through a turbo gear. The latter has a reduction ratio of 3.66 to 1, giving a tail shaft speed of about 93 revolutions per minute with an engine speed of 340 revolutions per minute. An efficiency of 98 percent is claimed for the gear, and if this can be obtained the loss of power is insignificant.

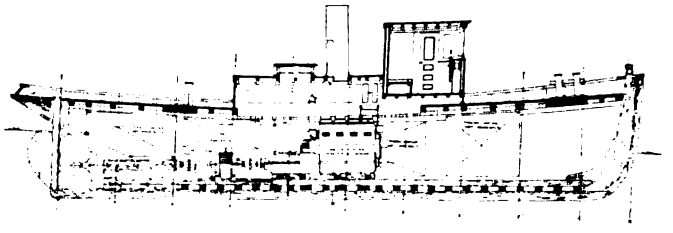

Fig. 2.—Inboard Profile, Showing Machinery Arrangement

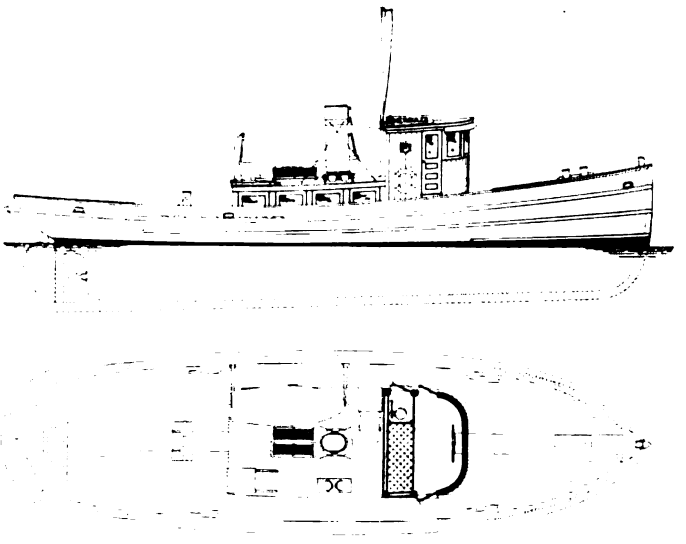

Fig. 3.—General Plans

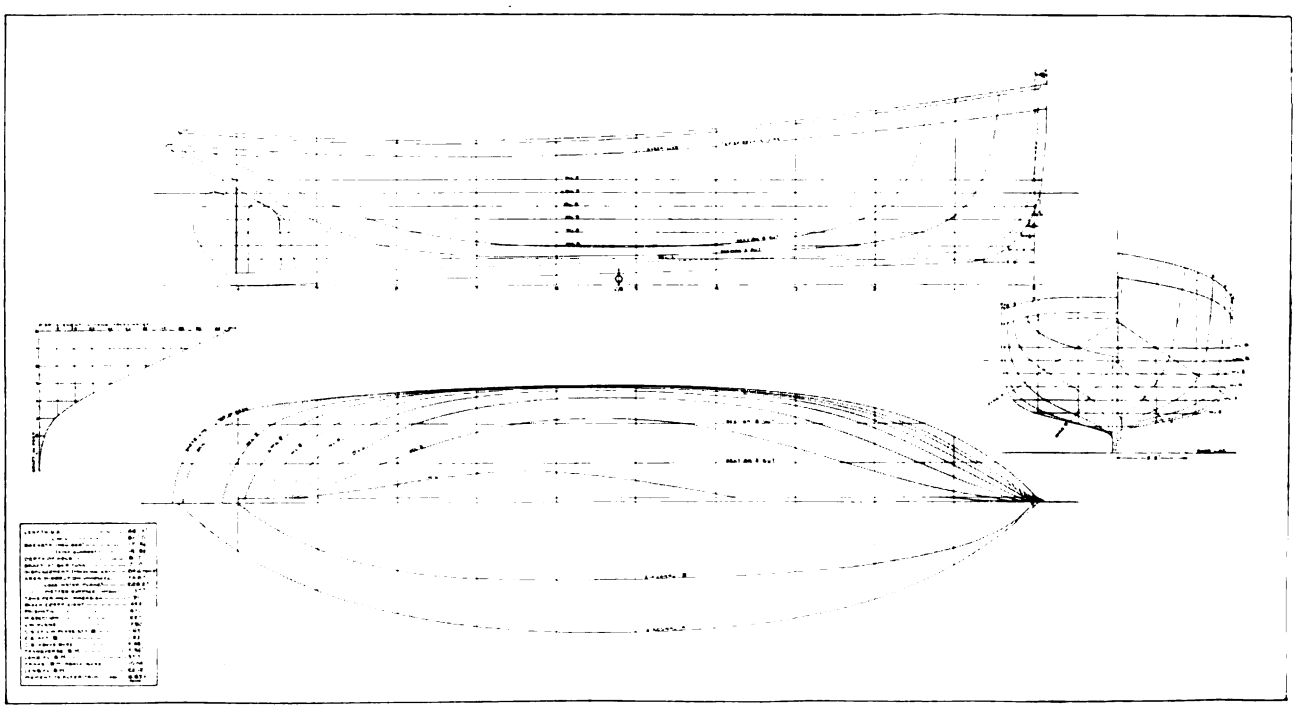

Fig. 1.—Lines of Oil Tug Designed by the Edwards Engineering Company

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Auxiliary Ketch Designed by Swasey, Raymond & Page and Built by Camden Anchor-Rockland Machine Company

The boat is intended for use as a fresh water carrier, as well as for towing, and the tanks shown have a capacity of about 8,200 gallons. The construction of the hull is substantial, and follows the usual practice in boats of this type. The cost of operation should be about half that of a steam tug and about one-sixth that of a gasoline (petrol) tug of the same power.

The principal dimensions are as follows:

Length overall	66 feet 2 inches
Breadth	17 feet 8½ inches
Draft (loaded)	7 feet 0 inches

Auxiliary Ketch Uvira

DURING the summer and fall of 1916 the Camden Anchor-Rockland Machine Company, Camden, Maine, built for Mr. R. B. Van Horne, from designs by Swasey, Raymond & Page, naval architects, an auxiliary ketch 79 feet overall, 55 feet long on the waterline, 16 feet 2 inches extreme beam, with a draft of 9 feet. The ketch was put into commission and taken over by the owner in the spring of 1917. She has been named *Uvira,* and is a splendid example of the best modern practice in yacht building.

The hull is built of the finest selected material. The planking is of yellow pine, the frames of Maine gray oak, the decks of Oregon fir, the trunks of teak and the finish in the cabin of white enamel and mahogany. The sails for the vessel were made by Wilson & Silsby, of Boston, and the auxiliary power consists of a four-cylinder model D Sterling gasoline (petrol) engine. Fuel tanks are provided, with a capacity of 400 gallons, and tanks of 300 gallons' capacity are fitted for fresh water.

The yacht is lighted throughout with electricity and also by acetylene gas. Under auxiliary power she makes a speed of better than 8 knots.

Ferro Concrete Vessels*

THE recent experiments in the construction of ferro-concrete vessels have aroused an unusual degree of interest, and shipyards for the construction of such vessels have been, or are about to be, started in several places. Reinforced concrete vessels are by no means new. During the last six or seven years several have been constructed experimentally, but little or no progress on a commercial scale has so far been made. It is probably only the shortage of tonnage resulting from the war and the difficulty of obtaining the ordinary raw materials for shipbuilding which have caused engineers to take up the question in earnest.

It may be of some interest to mention a few isolated examples of ferro-concrete vessels built within the last five or six years. In the autumn of 1911 one of the Danish boards of engineers commenced the building of a barge or lighter of the following dimensions: Length, 47 feet 6 inches; breadth, 13 feet 10 inches; and depth, 5 feet 10 inches; carrying capacity, about 27 tons deadweight. It was built of ferro-concrete, both the design and the construction being in experienced hands. It was taken into use in the following spring. In the design much attention was paid to the protection of the bows and sides against impact, heavy fenders of wood being attached to all the exposed places by means of bolts cast into the reinforced concrete. The inside of the vessel was also effectively protected by wood. This lighter has proved quite satisfactory, and no drawbacks have been found to attach to the material used. Some time previously the Danish Royal Dockyard had ordered some ferro-concrete pontoons for a floating bridge. They served satisfactorily for some time, until one night during a heavy gale from the north, which caused considerable sea in the outer harbor, a good-sized hole was chafed in one pontoon by a piece of floating timber between it and the pierhead, with

* From Engineering.

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the result that the pontoon was filled with water and sank, carrying down the other pontoons and the entire bridge. At about the same time the dockyard built some ferro-concrete pontoons for a piledriver float. These have proved satisfactory. They are protected against chafing by wooden fenders on the sides and other exposed parts. The report from which the above details have been obtained states that experience has shown that ferro-concrete, rightly designed and constructed by men skilled in this special branch, may prove a reliable material for floating constructions, including vessels, provided that they are effectively protected against impact and chafing, etc.

In Germany and Holland several small craft have been built of ferro-concrete during the last few years, and quite recently lively interest has been taken in the matter. In Hamburg a ferro-concrete lighter was taken into use in the coal harbor some three or four years ago; the bottom, the sides, the frame, and all the ribs were of reinforced concrete. It comprised some small watertight compartments, but the cargo space was entirely unobstructed. The more exposed portions were also in this case protected by broad wooden fenders built into the concrete.

A Stettin firm built a motor boat of ferro-concrete some five years ago. The vessel was divided into four compartments by bulkheads, which also served to stiffen it. The motor rests on wooden beams, which are attached to a concrete foundation. It is of the two-stroke type, and of 5 horsepower. This vessel has been used as a pleasure boat and apparently has given satisfaction. Also in Holland ferro-concrete boats of modest dimensions have proved efficient. The first ferro-concrete motor boat on the Boden lake was put in the water at Constanz some five years ago. In Russia the use of ferro-concrete vessels for coasting and river traffic has also commenced, a French vessel built at St. Rafaele being accepted as a model. Russia is rich both in cement and sand, in addition to which ferro-concrete vessels are fireproof, which is considered a great advantage in a country where fires on board the river craft are stated to be frequent. For the transport of naphtha products, boats built of this material are considered particularly well adapted.

The instances referred to above are all small boats, which, though apparently satisfactory enough, did not lead to anything approaching a regular industry. This, however, has now been instituted. We have already several times referred to the subject in connection with the Norwegian yard exploiting the Fougner patents. In Sweden one cement-working concern has constructed some barges, used for transport in their own business, and another similar firm is also about to make a start in the same direction. In Denmark, too, the matter has now been taken up.

The Fougner Company at Moss has recently obtained the necessary permission from the Norwegian authorities to commence the construction of two ferro-concrete vessels, without waiting for the final report from the Concrete Ships Committee. The two vessels are of respectively 600 and 1,000 tons, and the fact that the government has given this dispensation shows that a considerable interest must be taken in this new material for shipbuilding. The vessels in question will have four watertight bulkheads, double bottoms of ferro-concrete, and water ballast tanks fore and aft. In deference to the requirements of the authorities these new vessels are built about 20 percent stronger than the yard would normally make them, which, however, does not mean an increase of 20 percent in the weight of the vessel. The dimensions for the 1,000 tons boat, of which we reproduce an

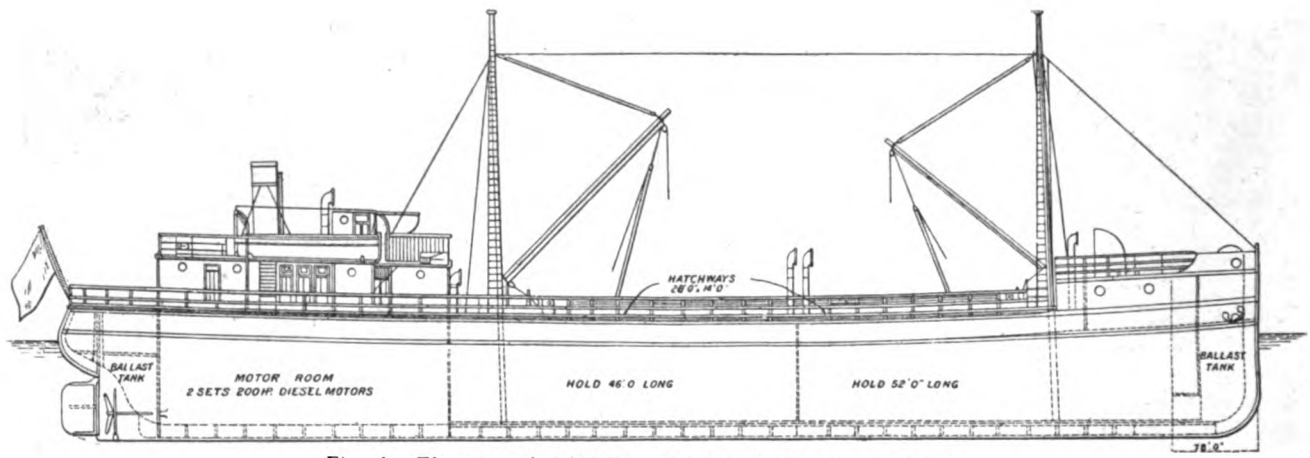

Fig. 1.—Elevation of 1,000-Ton Reinforced Concrete Motorship

elevation, are: Length, 166 feet; breadth, 31 feet; depth, 18 feet. The authorities have stipulated for a particularly ample equipment with regard to life-saving appliances, and the first ferro-concrete vessels will have to undergo special tests before the delivery can take place. The boats resemble the so-called canal-barge type, which is well known both in Norway and Sweden. The propelling power is supplied by two Bolinder crude oil motors of 200 horsepower each. The first two Norwegian concrete vessels are expected to be ready in the course of October. Another Norwegian yard is taking up the construction of good-sized ferro-concrete vessels, and intends to make a specialty of standard types.

In one respect Denmark seems to have taken the lead in connection with ferro-concrete shipbuilding, inasmuch as official rules have been laid down for designing such vessels; neither Norway nor Sweden has, so far, found it convenient to issue such regulations. The Danish rules have been worked out by the well-known expert in ferro-concrete matters, Professor E. Suenson, of the Polytechnical High School, Copenhagen, who is a member of the committee on ferro-concrete vessels. The rules apply to the building of small flat-bottomed vessels of ferro-concrete.

Basis for Calculations

The dimensions are to be fixed on the basis of the Union of Danish Engineers' rules for structural work in ferro-concrete, subject to the following regulations.

The bottom and sides must be at least 7 centimeters (2.8 inches) thick. Flat surfaces less than 8 centimeters (3.2 inches) thick are to be considered as simply supported

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unless so reinforced as to be capable of withstanding bending moments in both directions.

The tensile stress on the metal must not exceed 8 tons per square inch; the compressive stress on the concrete must correspond to a factor of safety of 7, or a maximum of 800 pounds per square inch. When the calculated shear stress on the concrete exceeds one-tenth of the compressive stress provision must be made for taking it wholly on the metal reinforcement.

In calculating the strength of the hull the vessel is assumed to be riding on a trochoidal wave of length L, equal to the length of the vessel between perpendiculars and with a height equal to one-twentieth of the length. The cargo compartment is taken to be fully laden with a homogeneous cargo. The calculation is to be made both for the condition when the vessel rides on a wave crest and for that in which it lies in the trough.

The transverse strength is provided for on the hypothesis that the vessel is fully laden, but in such a manner that the cargo is evenly distributed over one-half the total area of the hold while the other half is free. The maximum external pressure to be provided for is that due to the draft

$$\pm \frac{L}{40},$$

where L is the length between perpendiculars. No allowance is made for any distributing effect of the longitudinal girders. The bottom of the hull is taken as a beam subject to a uniformly distributed load q and to the bending moments due to horizontal thrusts H applied at the point at which the sides and deck girders intersect (see Fig. 2).

Fig. 2.

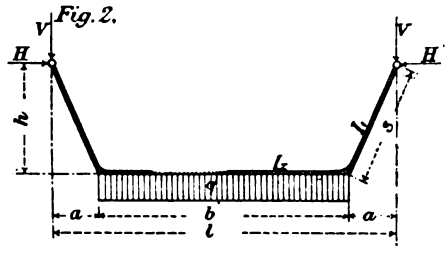


Fig. 3.

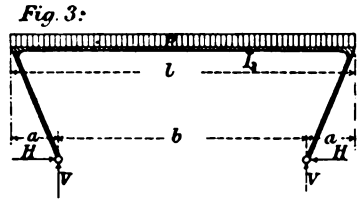
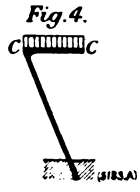


Fig. 4.



Figs. 2-4.—Basis of Strength Calculations

The direct action of the water pressure on the sides is ignored, but is provided for in fixing the value of H, for which the following formula is adopted:

$$H = \frac{q\,b}{4\,h}\left\{\frac{b}{3 + 2\frac{I_2 S}{I_1 b}} + 2\,a\right\}$$

Here q denotes the uniform load per square foot on the bottom of the hull, while I_2 and I_1 represent the moments of inertia of the cross sections of the bottom and sides respectively.

The stresses are calculated for the two values of q, viz.:

q = maximum water pressure — w,
and q = minimum water pressure — w,

where w denotes the weight per unit area of the floor plate.

The side ribs are investigated for the same two cases of loading as the bottom plate, and also for the cases represented in Figs. 3 and 4.

The deck is dimensioned for a load of not less than 700 kilogrammes per square meter plus its own weight.

The through deck girders are assumed to form in conjunction with the side ribs a two-hinged frame, the hinges being at the points where the center lines of the side ribs intersect the center line of the bottom (Fig. 3). The following value is assumed for H:

$$H = \frac{p\,l}{4\,h}\left\{\frac{l}{3 + 2\frac{I_2 S}{I_1 l}} + 2\,a\right\}$$

where I_2 denotes the moment of inertia of the deck beam.

The stringer plate c—c (Fig. 4), as a horizontal girder, must be able to transmit the horizontal pressure H (Fig. 1) to the through-deck girders at the end of the hatch. These deck girders are dimensioned for the horizontal pressure represented in that figure and also for the value of H corresponding to Fig. 2.

Watertight partitions are required to withstand water pressure from either side full up to deck level. Safety against local damage by collision is to be provided by giving the vessel such a shape that under normal conditions it can only be hit above the waterline. After completion the hull is to be painted up to the loadline with asphalt, coal tar or similar waterproofing coating.

The Science of Naval Architecture

(*Concluded from page 481.*)

hitherto the naval architect has not been required to consider as regards merchant ships. If present piratical methods of war at sea are to continue, the distinction between merchant and war vessels will necessarily disappear.

As regards vessels of war, experience to date has shown broadly that the science of naval architecture has provided ships which function as anticipated. The enormously destructive weapons of the day are able to destroy in time anything that floats, and without disparaging Mahan's dictum that "Good men in poor ships have always won over poor men in good ships." There is no doubt that good ships are essential even to the best men. Our ships are now to undergo the "trial by ordeal" of the features carefully and patiently planned in past years. May they prove worthy of the good men that man them! There is one final thought, however, which naval architects the world over feel to-day. The progress of late years, which has seemed rapid, will seem slow indeed by the side of the progress and development which must and will be made during the years just ahead of us.

The science of naval architecture, whether applied to vessels of war or peace, has a weighty part to play as the world undertakes to meet the changed conditions of war time and of the time after the war.

NEW GERMAN BATTLE CRUISER.—According to reports from Berlin, a large battle cruiser, named the *Graf von Spee*, was launched recently at Danzig, showing that Germany has not wholly abandoned the building of capital ships in favor of submarines. It is understood that the vessel is heavily armed, probably with eight 15-inch guns.

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CANADIAN REINFORCED CONCRETE SHIPS

Building by Atlas Construction Company, Ltd., Montreal

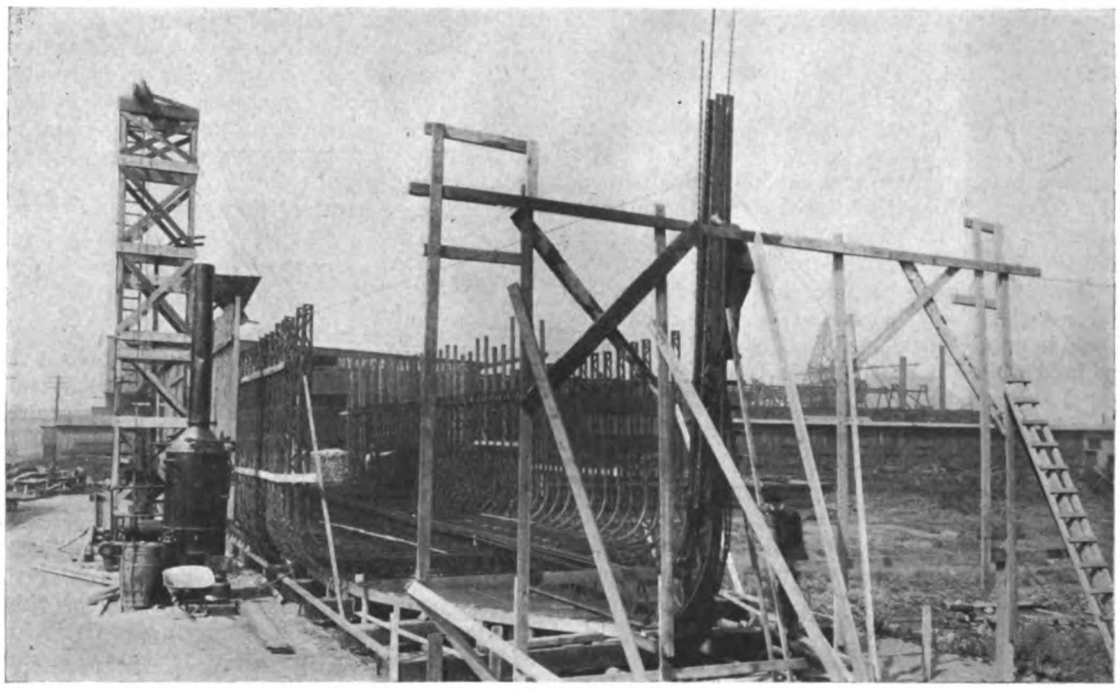

Fig. 1.—Steel Frames of Vessel 5 Inches Wide at Top, 14 Inches at Bottom, Spaced 27 Inches Center to Center

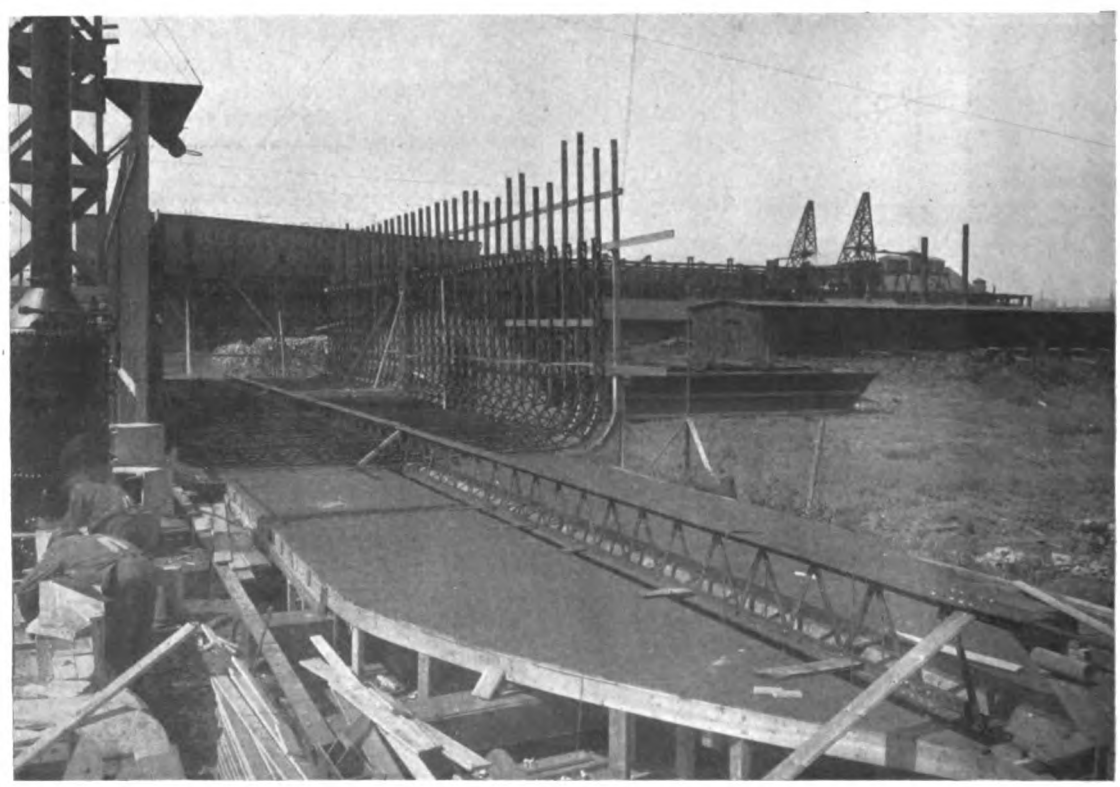

Fig. 2.—Vessel Being Constructed in Accordance with Plans by C. M. Morrsen, C. E., and Prof. Ernest Brown, of Montreal

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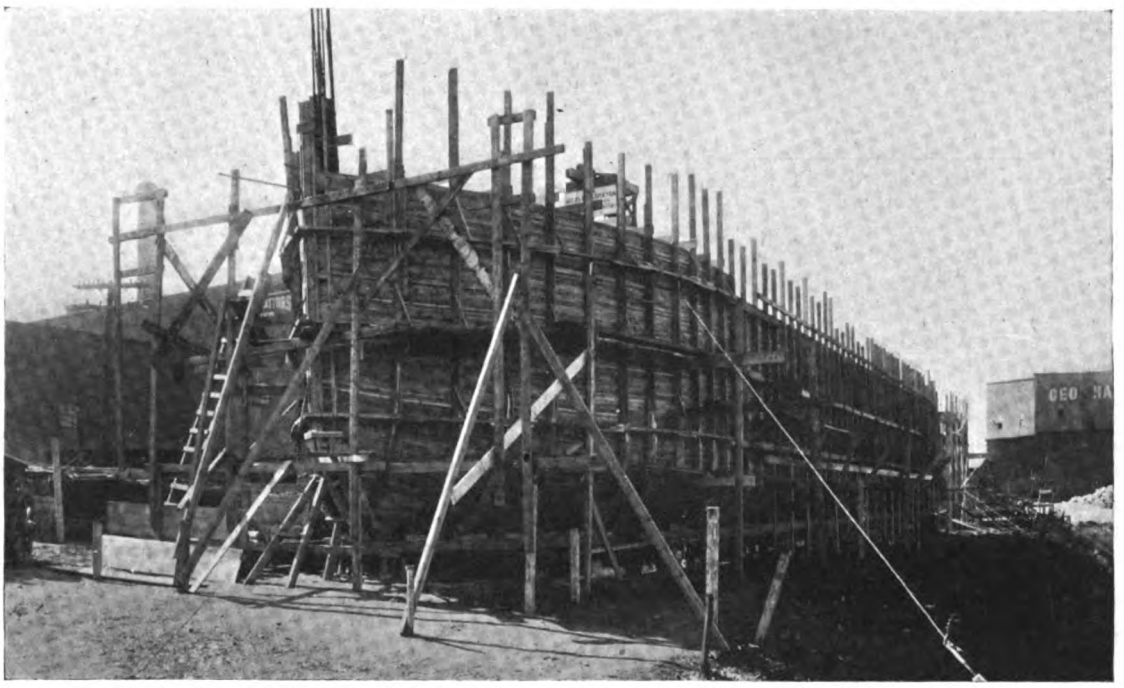

Fig. 3.—Completed Vessel Will Be 125 Feet Long, 22 Feet Beam and 13 Feet Molded Depth, Driven by Single Screw at Speed of 8 Miles per Hour

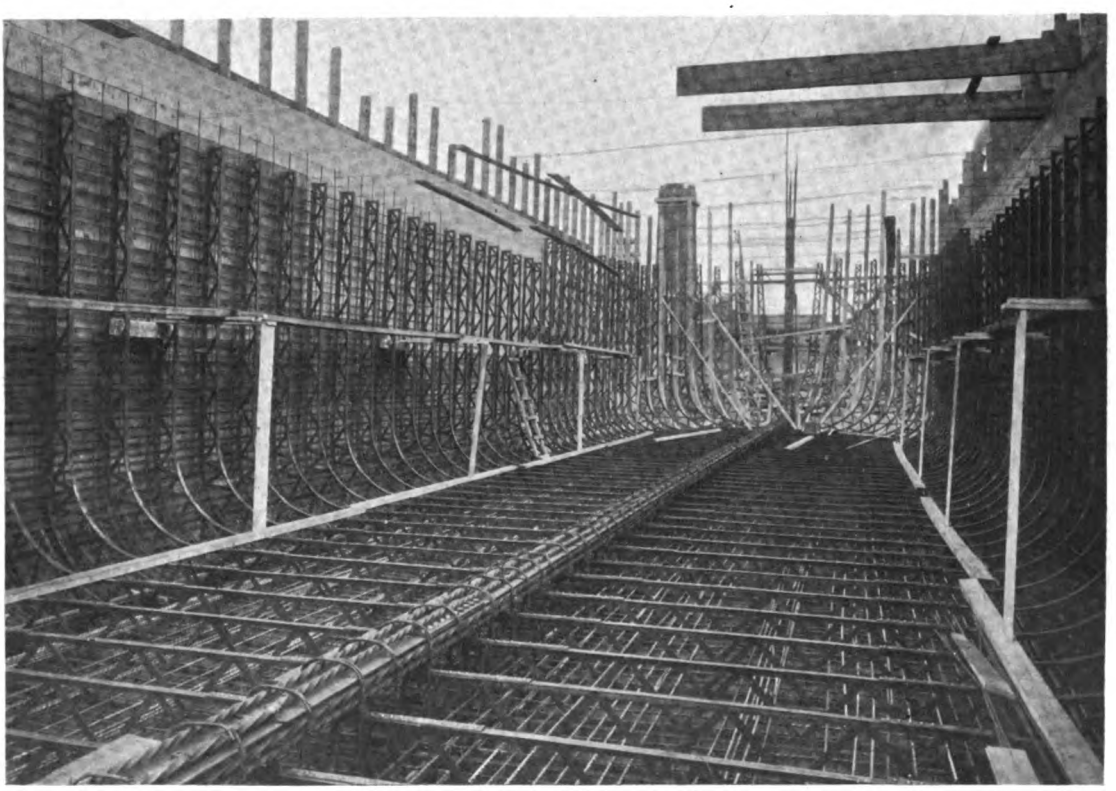

Fig. 4.—Interior View Showing Steel Reinforcements of Hull. Concrete Shell Will Be From 3 to 5 Inches in Thickness

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Development of Machinery in the United States Navy During the Past Ten Years*

Refinements in Design of Reciprocating Engines—Comparative Performances of Scout Cruisers—Adoption of Turbines—Forced Lubrication

BY CAPTAIN C. W. DYSON, U. S. NAVY

WHEN I assumed duty as first assistant in the design division of the Bureau of Steam Engineering of the United States Navy Department in July, 1906, I little realized that I was being put in a position where opportunity would be offered me to participate in the greatest advances in marine propulsion that the history of marine engineering has ever known.

During the period covered by this paper we have seen the marine reciprocating engine reach its highest point of development, only to be superseded by the steam turbine, which, as in the case of the older engine, was directly connected to the propeller shaft. The direct-connected turbine has had only a short life, and at the present time is rapidly disappearing from the marine stage, its place being usurped by the mechanical and the electric reduction drives.

Coincident with these changes in the types of steam engines for propelling machinery has occurred the development of the internal combustion engine as illustrated by that most important of the type, the Diesel engine.

Accompanying the advance in main propelling engines were improvements in boilers, in air, circulating and feed pumps; in forced draft blowers; the adoption of oil for fuel in place of coal, and the development of a method for the more accurate design of propellers for the conditions under which they were to operate.

It is my intention to take you through the marine engineering history of these past ten years as I have seen it in order to give you in the limited time at my command as clear an understanding as possible of what has been done and of why it was done.

Conditions in 1906

Upon assuming my duties in the Bureau of Steam Engineering, of the various vessels under construction there were only five whose machinery plants have had any influence upon design during the period of development of subsequent years. These five vessels were:

Battleships—*Michigan* and *South Carolina*.

Scouts—*Birmingham, Chester* and *Salem*.

The two battleships, aside from their interest as the forerunners of the dreadnaught and super-dreadnaught classes of vessel, were of interest from an engineering point of view on account of having the first examples of perfected reciprocating engines for main propelling engines and on account of being the first vessels in the navy to be originally built with superheaters applied to the boilers.

The scouts were particularly interesting, as two of them carried the first installations of turbine-propelling machinery that existed in our navy, the *Chester* being fitted with a four-shaft arrangement of Parsons reaction turbines, while the *Salem* had a two-shaft arrangement of what is known as the Curtis velocity-compound impulse turbines. The third vessel, the *Birmingham*, was fitted with high speed reciprocating engines in order to give a thorough comparison of the three systems.

Valuable lessons were taught us by both battleships and scouts. The lessons were as follows:

Lessons from Michigan and South Carolina

Engines.—The engines of these ships were fitted with piston valves of such length that the steam ports were perfectly straight and entered the steam cylinders in the plane of the diameter. This change from the old system, in which the valves were short and the steam passages long and crooked, permitted the use of ports of larger cross-sectional area, resulting in a decrease in steam velocity through the ports with consequent reduction in steam pressure drop between the valve chest and cylinder, while at the same time a very considerable reduction in the volume of the ports and, consequently, in the total clearance volumes, was realized. The clearance percentages of the old type of engine, referred to the volumes swept by the different steam pistons, averaged about

H.P. cylinder	22½ percent
I.P. cylinder	18½ percent
L.P. cylinders	16 percent

With these first engines of the new type these clearances were reduced to

H.P. cylinder	12⅛ percent
I.P. cylinder	12 percent
L.P. cylinders	11.8 percent

Again, in the old type of engines the cylinder ratios, neglecting clearances, were

$\frac{\text{I.P.}}{\text{H.P.}}$	2.66	say 2⅔
$\frac{\text{L.P.}}{\text{I.P.}}$	2.65	say 2⅔
$\frac{\text{L.P.}}{\text{H.P.}}$	7.046	say 7

These ratios gave an expansion of the steam of about 9, and while such ratios of cylinders tend to light weight, they also produce low economy at full power on account of the low ratio of expansion.

In order to increase the economy of the engines, the cylinder ratios of the *Michigan* and *South Carolina* were made

$\frac{\text{I.P.}}{\text{H.P.}}$	2.64	say 2⅔
$\frac{\text{L.P.}}{\text{I.P.}}$	3.83	say 3⅞
$\frac{\text{L.P.}}{\text{H.P.}}$	10.13	say 10

This change in ratios increased the expansion of the steam to about 12, and reduced the mean effective pressure as referred to the L.P. cylinder from about 55 pounds to 35 pounds per square inch of L.P. piston area.

As previously stated, the boilers of these vessels were fitted with superheaters. The original estimate of the

* From the Journal of the Society of Naval Engineers.

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amount of superheat which could be realized from the amount of surface provided was about 100 degrees F., but on trial the superheat at the H. P. valve chest only reached 86 degrees. As the percentage gain in economy by the use of superheat is roughly estimated at 1 percent for every 10 degrees, the superheat gave a gain of 8.6 percent in economy.

The actual gain in economy of the engines of these vessels was, however, considerably in excess of this, although the exact amount is not known, the water consumption of the engines not having been measured. The fuel measurements, however, showed a coal consumption of 1.46 pounds per hour per horsepower of all machinery in operation, which, when compared with 1.775 pounds, that of the *New Hampshire,* one of the last of the vessels having the old type of engine and no superheat, indicates a total gain of 21½ percent. The difference between 21.5 and 8.6, 12.9 percent, is a rough measure of the gain due to the changes in the engine proportions and design. This gain will later be shown to have actually occurred, as in later engines the water consumption was actually measured.

OTHER POINTS OF INTEREST

In laying out the main steam piping of the *Michigan* an attempt was made to eliminate all slip joints by the use of generous bends in the pipes and thus rid ourselves of the trouble due to leaks from such joints. The results obtained were very unsatisfactory, as steel piping of the diameters used, 7 inches to 12 inches, was too stiff to expand freely with the amount of bend that could be installed. It was found impossible to keep the flange joints tight, and the entire system had to be replaced by piping fitted with slip joints.

A departure in the material for the main feed system was also made. In previous ships the feed piping had been of seamless drawn copper throughout. On the *Michigan* all feed piping of 5 inches diameter and over was made of seamless drawn steel.

Forced Draft Blowers.—In regard to these, the two battleships also marked the beginning of an epoch; while preceding vessels had all been fitted with blowers of large diameter and slow speed of revolution, driven by reciprocating engines, on these new ships blowers of a type known as the Sirocco were installed, and these were driven by electric motors obtaining their current from the ship's electric plant. While the old-type fans were run at only 225 revolutions, the new type ran at about 650, resulting in much smaller, lighter machines, and by the replacement of the reciprocating engines by electric motors, vastly increasing the durability and the reliability of the system.

THE SCOUTS

These vessels, *Birmingham, Chester* and *Salem,* are chiefly interesting as marking the definite abandonment of the reciprocating engine for light, high speed work and the adoption of the turbine in its place, the reciprocating engines of the *Birmingham* having been fitted for the purpose of obtaining a comparison of the economy and reliability of the two types of machinery.

The engines of the *Birmingham* ran at 200 revolutions, those of the *Salem,* which vessel was fitted with Curtis turbines, at 350 revolutions, and those of the *Chester* at 502 revolutions, the engines developing 16,000 indicated horsepower for the *Birmingham* and 16,000 shaft horsepower for each of the other two vessels, the steam pressure being 250 pounds per square inch, gage.

While the *Chester* was the first example of Parsons turbines in our navy, this type of turbine had been so thoroughly developed in all its details before being pushed forward as a competitor of the steam engine that the installation fitted to the *Chester* was similar in its arrangements and mechanical details to all subsequent vessels in which this type of turbine was installed. The turbines were arranged on four shafts, with an H.P. on one and an I.P. cruising turbine on the other of the two inner shafts. While later vessels with four-shaft arrangements were fitted with backing turbines on all shafts, the *Chester* differed, and backing turbines were fitted to the inner shafts only.

The *Chester* was a successful ship from the outset, as was the *Birmingham,* and both vessels reflected credit upon their builders.

The experience with the *Salem,* however, was far from satisfactory, and the reasons are not difficult to find. In tracing them out it will be well to give a short sketch of the progress of the Curtis turbine up to the date of completion of the *Salem.*

The Curtis turbine is of the type known as "impulse velocity compounded." It had been used quite extensively on shore for driving electric generators before the marine type was designed. The type used on shore being built as vertical units, it became necessary to depart from this form to adapt the turbine for use on board ship.

At this early date the theory of this turbine carried with it the idea that as all expansion of the steam took place in the steam nozzles, wherein steam pressure was changed into velocity, there was no change in pressure throughout the blades of any one stage, and that thereafter there was no unbalanced steam thrust on the rotor of the turbine.

The earliest marine application of the Curtis turbine occurred on the yacht *Revolution* in about 1902. These turbines were provided with only two stages, and developed S.H.P. equivalent to 1,800 I.H.P. at 672 revolutions. A board of naval engineers reporting on the performance of these turbines in 1903 stated: "This plant, being the first large set of steam turbines installed for screw propulsion in the United States, it seems appropriate to mention that the general performance of these turbines, although themselves built rather in the nature of experimental appliances, was quite satisfactory, and they are well adapted as a type of motor for the transmission of propulsive power." * * * "The points in conjecture with regard to these machines being their efficiency and their capacity to compete in economy with the best marine engines, should be ascertained by more accurate tests, both on land and on board ship, where this is possible. The opinion of the undersigned (the board) is that such tests are warranted, and eventually will result in the application of a motor for screw propulsion highly satisfactory to the naval service."

Following this report, the Southern Pacific Steamship Company placed an order with the Fore River Shipbuilding Company for the construction of the steamship *Creole,* to be fitted with Curtis turbines, and in 1905 the Navy Department contracted with the same company for the construction of the *Birmingham* and *Salem.*

The turbines of the *Creole* and *Salem* were made practically from the same patterns, the nozzle areas of the *Salem* being, however, twice as great as those of the *Creole,* on account of being called upon to deliver twice the power. The turbines were built with seven-wheel stages, the drum type of Curtis turbine not having yet appeared upon the scene.

The turbines of both of these vessels were fitted with a type of blading which "hind sight" has taught us was so weak as to be a serious menace to the reliability. The diaphragms between stages were made each in one piece,

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and to overhaul the shaft packing of any diaphragm required that the turbine shaft be completely stripped up to and including the desired diaphragm. Further, the thrust bearings were made completely independent of the turbine casings, which was a serious mistake, as these bearings should come and go with the turbine as it expands or contracts. Also, in the case of the *Salem*, while the turbines of the *Creole* were made rights and lefts, those of the *Salem* were made rights only, the port turbine being exactly the same as the starboard, but being turned end for end when installed in the ship. This resulted in adding the unbalanced axial thrust of the turbine to the propeller thrust and unduly overloaded the thrust bearing and its support, and has been a continual source of trouble ever since the vessel went into service.

A comparison of the machinery weights of the three scouts will be interesting, both actual weights and weights per actual power developed on trial.

The total weight of machinery installation, including propelling machinery, auxiliary machinery, piping, boilers and fittings, smoke pipes and uptakes, lagging and clothing, flooring, ladders and gratings, fittings and gear, stores, tools and spare parts carried on board, and pipes, valves, etc., connected to machinery not under cognizance of the Bureau of Steam Engineering was

	Dry	Wet
For *Birmingham*	760.82 tons	843.97 tons
Salem	853.85 tons	908.96 tons
Chester	735.87 tons	800.69 tons

The weight per horsepower delivered was

		Pounds
For *Birmingham*	(I.H.P.)	117.18
Salem	(S.H.P.)	112.68
Chester	(S.H.P.)	89.67

Turning now to the question of relative efficiencies of propulsion, and reducing the I.H.P. of the *Birmingham* to S.H.P. by multiplying by .92, the S.H.P. per knot speed per hour required were as follows:

Knots	10	15	20	24	25
Birmingham	92	156	331	563.5	
Salem	97.5	193	380	600	710
Chester	80.?	190	362.5	604	758

These power results are not particularly consistent, due, probably, to the characteristics of the hulls of the vessels and to variations in weather conditions under which the trials were held. There may also have been errors in the torsion-meter readings, especially at the low speeds, where a slight error would produce the greatest percentage error.

Now, the true measure of efficiency of propulsion is not horsepower required for any speed, but is either steam consumption or fuel consumption required to produce the speed. Where oil fuel is used the personal element of the operating force is reduced to a minimum and measurements of fuel are preferable to measurements of steam consumption, as the first gives a gage on the efficiency of the entire machinery plant, including boilers, while the latter gages the efficiency of the engines and auxiliary machinery only. Where coal is used as the fuel the personal equation of the fireroom force enters largely into the problem, and therefore measurements of steam consumption are to be preferred in such cases.

The steam consumptions in pounds per hour of the three vessels, for all purposes, on these trials were as follows:

Knots	10	15	20	24	24.5
Birmingham	34,000	66,000	134,000	285,500	
Salem	44,000	84,000	150,000	273,000	300,000
Chester	43,200	76,500	138,500	254,800	284,000

The steam consumptions of the main engines, only, at these speeds were

Knots	10	15	20	24	24.5
Birmingham	21,000	50,400	113,000	247,000	
Salem	29,900	66,700	127,300	238,000	261,800
Chester	24,250	56,200	118,000	218,000	244,000

Pounds of water per hour per S.H.P. (main engines only):

Knots	10	15	20	24	24.5
Birmingham	22.82	21.6	17.06	18.26	
Salem	30.7	23.	16.8	16.50	14.75
Chester	30.3	19.72	16.27	15.03	13.34

Attention is called to the fact that while the total steam consumption with reciprocating engines is decidedly better below about 22 knots than that of either the Curtis or the Parsons turbines, even though the latter are fitted with cruising turbines which are in use from 20 knots down, the economies are about even at 22 knots, and above that speed both types of turbines have a decided superiority. Hence, in cases where high speed and light weight were the prime factors to consider in the design of machinery for a vessel, some type of turbine machinery was always to be preferred over reciprocating engines. In cases where the speed of vessel was comparatively low, where high speed was seldom called for, and where economy of propulsion at cruising speeds was of paramount value, the reciprocating engine was, under the conditions of turbine design existing at this early date, very much to be preferred.

For several years after the adoption of turbines as a prime mover for marine propulsion the turbine designers and builders successfully blinded the public concerning the performances of turbine vessels by comparing the steam per horsepower required by turbines with that required by reciprocating engines, and, as shown by the comparison of these amounts for the scouts, the argument was a very good one if the material data necessary to reduce the figures to figures of pounds of water per knot run were not available.

Leaving these vessels, we now reach the starting point of what may be called the modern navy.

1906-1907

During the summer of this year work was begun on the plans of our first two dreadnaughts, and for two, afterwards increased to five, high speed destroyers.

The plans for the dreadnaught were prepared in competition with outside firms, and, while a nominal speed of 20 knots was provided in the design, sufficient reserve power was installed to insure of 21 knots being attained.

When the competitive plans were examined by the department those prepared by the department were adopted and work on the contract plans and specifications at once started.

The machinery space provided in these vessels was such that only reciprocating engines or turbines of the impulse or impulse-velocity compounded type, similar to those of the *Salem*, could be installed. The department plans showed reciprocating engines designed on the same lines as those of the *Michigan* and *South Carolina*, the cylinder diameters as designed being 36 inches, 57 inches and two of 76 inches, with a stroke of 4 feet. The contractors, fearing a lack of power in these engines, later increased the diameter of the H.P. cylinders to 38½ inches, a change which was unnecessary for a speed of 21 knots, but which resulted in considerably higher speed of ship.

The plans also showed Babcock & Wilcox boilers fitted with superheaters, the superheating surface being 10 percent of the total heating surface. While in earlier vessels, in designing the boiler installations, the empirical rule used had been 15 I.H.P. per square foot of grate surface and a ratio of 44.5 to 1 between heating and grate surface, in the design of these vessels the allowance was 18 I.H.P. per square foot of grate and a ratio of 44.5 to 1 between total heating surface, including superheaters, and the grate.

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These dreadnaughts also marked our first step into the field of oil-fuel burning. When it was decided to fit these vessels with oil fuel the best sytsem to adopt was not known. The entire field of oil burning was carefully gone over, and it was determined to fit them with that system which would require the fewest number of changes from the ordinary coal-burning installations, especially as in the case in view coal was to remain the principal fuel, the oil only being fitted as an auxiliary to be used when coal became difficult to trim or in emergencies. This requirement made it necessary to adopt a system with which the forced draft blowers required by the coal-burning installation could be used, and we were therefore driven to the now well known system of "mechanical atomization," as it is called, although "pressure atomization" would more exactly define it.

In the arrangement of furnaces for burning either coal or oil the grates are fitted as for ordinary coal burning boilers, and the burners for oil, with the necessary slotted cones for the proper admission of air, are located between the furnace doors. Owing to the limited volume of the furnace between the tube roof of the furnace and the grates, only very limited quantities of oil can be successfully burned in such installations. The whole question of oil burning will, however, be discussed more fully later on.

Adoption of Turbines

Before the advertisements for bids for these two dreadnaughts were issued the first turbine-propeller battleship, the British original *Dreadnaught,* the name of which has been applied as a general name to the "all-big-gun battleship," had her trials, and the results were spread broadcast as a world advertisement for this new form of propulsion. It is spoken of here as a new form for the reason that up to this period it had only been used for much smaller, less important installations in destroyers and in the small Britisn cruiser *Amethyst.*

The installation on the *Dreadnaught* was of the very simplest type, there being four shafts with high pressure ahead turbines on two shafts and low pressure ahead and astern turbines on the remaining two. There were no means whatever provided for increasing economy at low speeds, and the expenditure of steam at these speeds was extravagant.

The new type of machinery, however, immediately struck both the public and the service fancy, and the Navy Department, yielding to the clamor in favor of the new fashion, invited bids for turbine machinery in addition to those for reciprocating engines.

As previously stated, the engine rooms on these vessels were too small to accommodate any other type of turbine than the impulse-velocity compounded type. When the bids were received a satisfactory bid was made by the Newport News Shipbuilding and Dry Dock Company for one ship built according to the department plans and specifications; that is, with reciprocating engines, while the Fore River Shipbuilding Company offered a satisfactory bid with guarantees of performance for a vessel with Curtis turbines.

The turbines offered were in general similar to those fitted in the *Salem,* but, inefficient and troublesome as they proved themselves later in actual service, they did mark one big step in the deevlopment of this now highly successful and economical American turbine, and the development of such a successful completed machine, in my opinion, completely justifies the early experiment and failure in the *North Dakota.* The improvement made consisted in increasing the turbine stages from seven to nine, the last four stages being carried on a drum in place of on separate stage wheels. This was the first appearance of drum construction with turbines of the Curtis and similar types, although it was, and is, the standard method for those of the Parsons type.

Until the advent of the Curtis turbine the Navy Department had been forced to go abroad for its turbine designs, a position which was extremely undesirable, and which justified experiment to the fullest extent to relieve us of the situation.

Forced Lubrication

During the building of the engines of the *Delaware* reports were received of the results obtained with forced lubrication on the reciprocating engines of the British battleship *Africa.* These reports indicated such a great improvement over the ordinary method of gravity lubrication that it appeared desirable to incorporate it in the engines building. Plans were at once prepared by the Bureau of Steam Engineering and forwarded to the Newport News Company, with a request that the matter be taken up at once and an estimate for the cost of the change be submitted to the department in order that authorization for the additional expenditure required for this improvement might be obtained. This was done, and, after some delay, the necessary authorization was obtained.

The original plans of forced lubrication for the *Delaware* contemplated applying it only to main and crank pin bearings and to the eccentrics, depending on the original gravity feed for lubrication of crosshead slides, wrist pins and valve link bearings, and, in conformity with this idea, only those parts having forced lubrication were covered in by the oil casing.

When the vessel was taken out for her preliminary acceptance trials the crossheads and slippers showed a tendency to run warm, and, before the trials, temporary connections through the water service piping were made from the forced lubrication system to these parts. The results obtained due to the forced lubrication were very marked, practically all the vibration and noise to which we are accustomed with the ordinary system of oiling being noticeable by their absence.

The trials, however, demonstrated the desirability of extending the forced lubrication to all the moving parts of the engines, and also that, when extended to the crossheads and slides, a large amount of oil was thrown on the piston rods and lower heads of cylinders, vaporizing on the latter, the oil on the piston rods and the oil vapor being drawn into those cylinders where pressures below the atmosphere existed. This oil then passed over to the boilers and caused fear of trouble due to the oiling up of the water side of the heating surfaces.

Development of the Piston Rod "Steam Seal"

The carrying of oil to the boilers being considered a serious menace, it was imperative that means to prevent it should be devised as quickly as possible, and in aiming at the preventive advantage was taken of the fact that for cylinders in which steam pressures lower than the atmosphere are apt to occur, the piston rod outer packing must be designed to resist pressure from the outside. As the M.P. and L.P. cylinders are those in which this condition exists, and as the high pressures carried in the H.P. cylinders tend to cause a blowing out of steam along the piston rod, cutting off the oil from the rod and preventing the entrance of oil vapor, it was necessary to apply the preventive to the M.P. and L.P rods only. The cure finally adopted is now known as the "steam seal," and consists of an outer stuffing box carrying about three rings of elastic packing with a space between the first or lower ring and the upper two, into which steam of a slightly

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higher pressure than that likely to exist in these cylinders is admitted. When the regular piston rod packing is properly fitted and is operating properly, the "steam seal" does its work efficiently. When the regular piston rod packing is not doing its duty the steam seal may aggravate the trouble by blowing through into the cylinders.

In service this system of lubrication proved so satisfactory that little time was lost in extending it to quite a number of the older vessels of the fleet where equally satisfactory results have been obtained. One of the commanding officers of the fleet made the remark to me that we had builded better than we knew, as the reciprocating engine fitted with forced lubrication was quite a different machine from the same engine fitted with gravity feed. Only the other day a report was recived in the bureau from one of the armored cruisers, stating that they had just overhauled their crank pin and main journals after a period of two years' running, and none of the bearings showed the slightest indication of wear. This in itself shows the immense decrease in work required to keep these engines in order over that required in the old days before forced lubrication was adopted.

(*To be continued.*)

Duties of Newly-Trained Marine Engineers on Merchant Vessels—I

Pointers for the Men Who Will Man Our Emergency Fleet—Service Routine Explained by an Experienced Engineer

BY C. H. WILLEY

THE call is being sounded throughout the United States for engineers to operate the great fleet of ships now being built and those to follow. Recently many ships were held up in port for a considerable length of time for lack of competent engineer forces to man them. Our naval engineers have trained a large number of navy men as engine runners and watch officers to man the seized German vessels. Schools have been established and special courses have been adopted in many of the leading colleges and universities for the special training of deck and engineer officers. Examination standards have been made less rigid, and many other inducements have been offered to attract men to our merchant marine fleet.

In response to this urgent call a great many are fitting themselves to take up the duties of a marine engineer. A large percentage of these men come from the ranks of our stationary engineers, and, with a little training and actual experience, these men will no doubt master the calling to a sufficient degree to entitle them to receive their marine engineer's certificate and a worthy billet on board ship. To these newcomers to the marine profession no doubt a few notes from one who has been following the sea will be welcomed as an aid. It is with that idea that the writer has attempted to scribe the following pointers:

Personal Outfit

It will be found both necessary and desirable to dispense at this time with carrying on board ship any excess baggage or personal belongings. A list of most needed equipment is suggested about as follows:

Prescribed uniforms for mess room and deck use (if no uniforms are required, then two suits of civilian clothes), four suits of light underwear, four suits of heavy underwear, four pairs of lightweight and four of heavyweight socks, four plain dress shirts, two blue flannel working shirts, four light working shirts, one pair dress shoes, two pair thick-soled work shoes, two dungaree heavy canvas or duck jumpers or coats, two dungaree heavy canvas or duck trousers, one dungaree union suit, heavy material, one reefer or medium-weight overcoat, four hand towels, two bath towels, the usual toilet articles and a few reference text-books that pertain to the type of marine engines and machinery of the vessel on which one is to serve.

Socks need be of the strongest material, for there are no women folk to do the darning. Thick-soled shoes will be found almost indispensable for standing watch on hot floor plates and the severe service of fireroom work.

Reporting on Board

About the first thing that the newcomer will want to do after reporting on board, getting acquainted and assigned quarters, is to get familiar with the general run of things below. Usually one of the boys who has been attached to the ship will take the new man in tow and show him the ins and outs of things, but this is only a starter.

One trip around will help, but falls far short of placing things impressively in one's mind. Each steam and exhaust line must be traced individually, noting particularly the several valves and their uses, the bulkheads and slip joints. When the ship is equipped with both a main and auxiliary line, the communicating valves should be well fixed in mind.

Next comes the feed system; this is perhaps the most important and should be carefully studied so as to know just what one can do in tight corners, such as when a feed pump breaks down. If you know the flexibility of the feed system you can quickly get another pump feeding.

The other lines, bilge, fire, circulating pump lines, etc., are all equally important, and must be familiarized to memory. The overhead piping comes fairly easy, but a deal of crawling and work is connected with getting next to that below the floor plates.

When an engineer has studied each line of pipe, its valves, their uses and location and become intimately acquainted with the machinery, he is equipped then, and only then, to be able to act with quickness and sureness in times of emergency, often being able to save both serious disaster to the vessel and the lives of his shipmates. One should never allow the lack of such vital knowledge to place the blame of a preventable happening on his shoulders.

Engineer of the Watch

After reporting to the chief engineer that he has the

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hang of things below, the newcomer is assigned to stand watch or day's duty below with one of the other engineers, and becomes posted on the operation of the engines and machinery, and is then given a watch of his own to stand.

Watches are generally stood in three sections, which means four hours on watch and eight hours off.

REPAIR DUTIES

Each engineer is assigned to a repair station. Generally there are but three stations—the engine room, the fireroom, the deck or auxiliary machinery. The newcomer will perhaps be assigned to the auxiliary station, and when in port or off watch he will find plenty to keep him busy on the repairs and upkeep of this station. By 'off watch' the writer means to imply that often an engineer has to stand his regular watch and then spend considerable of his own or off watch time in tuning up his repair station. When the ship's complement is sufficient there are but very few extra hours required of one to keep things in good shape, for then there are sufficient junior engineers, oilers and machinists to take care of the actual repair work, so that the engineer in charge has only to supervise the work, but if this be true it is well for the newcomer to learn to apply a little of the hard-earned skill that he has acquired as often as opportunities permit; otherwise one will get rusty and out of practice.

Usually there is provided a small machine shop and blacksmith outfit, for on board ship engineers are expected and required to make nearly all of the repairs, except the larger work, which goes to the yard shops. There will be need for the newcomer to learn to handle shop tools in a far larger measure than his stationary work on shore requires.

FIREROOM NOTES

No fireroom or boiler room is what might be termed a pleasant place to work in. But when the average boiler house on shore is compared with the stokehold of any vessel one might be tempted to think that tending a boiler on shore was a Paradise task.

About the first thing the writer did when he was introduced to a ship's fireroom was to look around for the best means of escape in case of a boiler accident, or the ship sinking, and perhaps it was a good thing, for a year ago, while serving on one of our cruisers, he was caught in an accident. Luckily, having thought out what I would do, I escaped death, but was severely scalded.

One thing to be borne uppermost in mind—those in firerooms caught in an accident should never attempt to climb a fireroom ladder; the escape must be made by crawling on hands and knees or running, if possible, to the nearest compartment. But should there be no other means of escape except that of climbing the ladder, something must be immediately wrapped around the head and face and a rag or some waste stuffed in the mouth.

While it is more comfortable to work in a scant amount of clothes about the fires, I would seriously recommend that heavy underwear be worn under the regular working clothes and heavy socks worn. This clothing will serve two purposes—that of absorbing the perspiration and of protection against more serious burns if a man is unfortunate enough to be caught in an accident.

OPERATION DUTIES

Just a few short remarks on the subject will serve to guide the new marine engineer as to what he will be expected to do. When getting up steam on coal-burning boilers, examine personally, or have a trusted man make sure before lighting off a dead boiler that all cocks and valves of it are in proper order. Oil lamps or candles should be on hand in the firerooms in case of the lighting system getting out of order. Spare gage glasses and packing should also be ready for possible need. Make sure that the dampers will open full and close tightly. Be certain that no inflammable materials are stowed on or near the boilers.

Make sure that grate bars are clear and in condition to receive coal. Men have the habit of using furnaces for stowing shovels, pails, etc. Once in my experience fires were being started in a dead boiler and we received the surprise of our lives on seeing a coal passer come flying out of the adjacent firebox door. He had crawled in there to steal a nap (the ship was in the tropics), and he said that he found the firebox of a dead boiler to be the coolest place to sleep—that when he opened the damper he lay on the bare grates, and went to sleep with the cool draft passing through.

LIGHTING OFF

Try the feed system to see that the checks are working. For lighting off, the water level should be about three inches in the gage glass; some prefer more, but if proper care is used in raising steam and cutting in, this is the best. The higher the water level the longer it takes to raise steam. Cover the grate with 2 to 3 inches of small lump coal not bigger than your fist, leaving about 15 inches of the grate bare near the door. On this bare grate live fire coals are placed, obtained from the auxiliary or donkey boiler. The fire will burn evenly back over the grate. As it burns, thinly spread the live coal with dry, green coal, and as the crust or top ignites, slice it up and shove lightly back; with a little care it will rapidly build up.

As soon as steam issues from the air cock on top of the boiler it should be closed and the try cocks and gage glasses immediately tested to see that they are clear by blowing through each one separately. In a reasonable time (say a minute after closing the air cock) the hand of the steam gage should register pressure that is formed. Should anything be amiss with these fittings the proper time to find out is before the boiler steam is allowed to raise to high pressure.

All coal is tallied by the bucket on board ship. Each bucket holds about 100 pounds. The usual plan is to weigh ten buckets in succession each watch, taking this weight as the average. A tally of the total buckets used per hour is entered in the steam log. All big lumps should be broken with a coal maul at the bunker door by the coal passer, to the size of a man's fist. Firemen have the bad habit of using the back of their coal shovels to break up large lumps that they find in the coal placed for them on the floor plates. This is the cause of many broken shovels.

When getting new boilers started, a considerable amount of fine, unburned coal is worked through the grates; this should be hauled from the ashpan and mixed with new coal; then refired.

While the steam pressure is rising, the auxiliary machinery in the fireroom and engine rooms should be made ready for steam, and the warming-up valves of the main engine cylinder jackets should be opened a little. The bearings of all the machinery are given a generous dose of oil by hand, and the oil wicks placed in, or the sight feeds regulated. Drains and exhaust valves are opened and the machinery jacked over one or two turns.

If sufficient steam is on the auxiliary or donkey boiler the main circulator and condenser can be started, opening the injection and discharge valves first, then starting the circulating pump and next the air or vacuum pump.

When the newly lighted boilers are nearing the working pressure they should be so checked that each will arrive at the blow-off point separately, say, at about ten-minute intervals. This gives time enough to cut in each one with care. The safety valves should always be tested, both by

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steam and the hand lifting device. After the valve has lifted, the boiler dampers and ashpan doors are checked up, and the steam pressure allowed to drop to that of the boilers on the auxiliary line, or to within a few pounds. Then the stop is gradually opened. When the main line is cold it must first be warmed up, and all slip joints and drain traps watched. Most main lines have a small by-pass from the auxiliary steam line through which steam is admitted until the pressure is equalized; then the large communicating valves are opened.

Some chief engineers allow the practice of opening all valves of the main line and stops of the dead boilers and raise steam with them open; this warms everything up gradually as the steam forms, but this scheme does not seem to be very popular. It takes considerable time and wastes coal and water.

Before turning over the main engines the stern tube shaft gland should be slacked back just enough to let the sea water drip through. The water service used to keep bearings cool should be examined and turned on.

Bilge strainers should be cleaned and all loose tools and gear stowed away. A plentiful supply of cooling lubricant or solution should be ready for possible troublesome bearings that may have been adjusted too close in port. Generally notes are available as to what has been done to the machinery while in port, and when under way these parts are given special attention.

All engine tell-tales, signals, telegraphs, voice tubes and means of communication should be tested out before reporting ready. An oiler is sent to prepare the steering engine and to stand by it until tested. When all ready to try out the main engines permission is obtained from the deck officer on watch, and then the engines are turned a few revolutions ahead and astern. If all is O. K., then the report is made to the chief engineer that the engineer department is ready to get under way.

Routine

When the ship is well on its voyage, or clear of the harbor, all ventilator cowls should be kept trimmed to the wind.

The speed of the auxiliary machinery is regulated to that of the main engines. The temperature of the condenser discharge is kept around 110 to 120 degrees to retain feed heat; this can be done on direct condensers by regulating the injection valve. The jacket steam pressure is reduced to just sufficient amount needed to keep the cylinders hot; oil wicks or feeds regulated to suit the standard speed.

Fires are cleaned in each new furnace once every 12 hours, but as a rule there is no need to clean new fires until they have burned a day. But all clinkers should be pulled as soon as they form.

Fires to be cleaned are first burned down to as near ash as the steam pressure will permit. While burning these down, the wing fires are built up to supply the new fire cleaned section of the grate. Time spent in cleaning should be reduced to a minimum, as during the cleaning, if care is not used, the steam will drop in pressure. Do not try to clean too many fires at one time.

Tubes must be cleaned free of soot and dirt once a day or they will soon plug up the draft passage. This is done with air pressure or live, dry steam used in flexible metallic hose with pipe lance leaders through the connection doors.

Coming Into Port

When it is known at what time the ship will anchor, the chief engineer issues orders as to which boilers shall remain in use for auxiliary. Then the remaining boilers are allowed to be worked or burned down as much as possible with due regard to the need of steam for anchoring maneuvers.

When dying out the fires it is best to close the dampers and ash pits and allow them to die slowly; this is best for the boiler and brick work.

In the engine room the main line stops and reversing engine are secured to prevent any accidental turning of the engines. Drains are opened, oil wicks and feeds are shut off, all cups and oil pipes leading to bearings are covered to prevent dirt getting into the journal. Gaskets or fillers are laid over ends of bearings. Air and circulating pumps are slowed down. A vacuum is kept on the engine until it is dried out and steam is on the main line. When able, the engine-room machinery is all secured and regular port duties of cleaning and adjustment are taken up.

(To be continued.)

Why Is A Gun Foundation?

Arrangement and Construction of Foundations for 5-Inch Guns on Merchant Vessels

CASEY had left us and gone to the "bush leagues." One of the first jobs he had been given was that of putting a gun foundation on a tanker which was about finished but which had to be supplied with a couple of guns, so that she could make her way with better success among the submarines. Casey's experience had been varied, but guns on merchantmen was something new. He was stumped, or thought he was, and had sent an S.O.S. call to "Old Mac."

Mac had written him a long letter. Before he mailed it, however, it occurred to him that its contents would benefit young Stevens. He, therefore, brought in his letter and gave it to young Stevens, with the suggestion that he read it and drop it in the mail box at noontime.

Young Stevens read it—studied it, in fact. With the idea that it might help other "bush leaguers," and may interest some of us in the major league, here it is:

Mac's Letter

DEAR CASEY:

You are worrying because that fellow you complain of is throwing a better bluff than you are throwing. Has he got your goat? If he is responsible and does not tell you the kind and number of guns and where he wants them located, why should you worry? Sit tight, smile and watch him try to make you do something that neither of you can do.

You are not telling me very definitely what you want to know, but I suppose you want to gather up what you can while there is time, so here are a few items as they occur to me.

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These auxiliary passenger boats have four guns, located port and starboard on the forecastle, and aft on the quarters. Four or five guns are used. The gun mount or pedestal base of the gun is bolted down to wood planking on the deck and enclosed in an angle bar that has a vertical flange which comes up to within about a half or three-quarters of an inch of the top of the wood, and a calked flange to the deck to suit the deck riveting. The wood is preferably teak, 3½ inches to 4 inches thick, and should have a level surface and not follow the camber or sheer.

Strengthening the Deck Plating

The deck plating in way of the foundation should be doubled to about 1 inch thick to give good bearing for the bolts. Another plate about one-half inch thick and called the washer plate takes the bottom ends of the bolts. This plate is loose and not fastened to the deck framing except by clips that prevent its falling out if the bolts are removed. This plate may be in several pieces and covers the wood filling of pine that is put in under the deck plating.

This wood filling stiffens the deck and allows a certain amount of play that makes the foundation resilient. The wood filling extends down to within two or three inches of the bottom of the beams or girders and is nicely fitted and sometimes filled with tar or pitch.

The holding-down bolts are made of high tensile steel. They are fitted in the gun mount and have a hexagon nut with a split pin on the bottom. They are a tight fit in the wood filling, being reduced about a quarter of an inch in diameter half way into the woodfilling. The size, number and location of these bolts are to be gotten from the detail of the gun mount to be used.

With no more than the maximum depression, the gun should have an unobstructed line of fire at an object on the surface of the water not more than 50 to 60 yards distant. The center of a 5-inch gun, as I remember, is about four feet above the deck, and the angle of depression is about 10 degrees.

A modern high powered gun of say 5 inches diameter bore has a trunion reaction of about 100,000 pounds or less and weighs about three tons. This trunion pressure depends upon the muzzle energy and recoil arrangements of the gun; and in the same gun with less muzzle energy, may run down to 50,000 pounds. This trunion reaction is the maximum reaction or kick of the gun on the trunion. These figures may be of service, if you want to attempt to analyze stresses, etc., in supporting beams and girders in any particular case.

Location of Guns on Freighters

On a tanker or freighter they are now fitting two guns, one forward and one aft on the centerline of the ship. As before, they should have an unobstructed line of fire at an object 50 to 60 yards ahead or astern on the surface of the water. They should train as far to port and starboard as possible. Deck space is not always available aft on these boats and there are obstructions forward, so that the guns may have to be mounted up in the air—clear above the deck on a platform over the windlass forward or on top of the deck house aft. The same kind of foundation directly under the gun is used as when mounted on the deck, except that it is raised up in the air and supported by girders and webs from the structure of the ship. Four girders crossing at right angles under the edges of gun mount and made up of ½-inch plate and 5-inch by 5-inch by ½-inch angles make a good scheme. For ordinary spans and a 5-inch gun, a girder of 12 inches to 15 inches deep is about right. Five-inch solid stanchions at the corners should be fitted if possible, and the framing should be carried down through two or three decks and distributed well into the main framing of the ship.

Working Platform

With a gun mounted in the air this way a working platform has to be provided for the gun crew. It is made large enough so that it extends about two feet beyond the working circle of the gun. It is supported from the main gun foundation by brackets and beams and can be plated and stiffened as for a housetop. For a 5-inch gun this working platform would be about 28 or 30 feet in diameter. It should have a coaming and permanent stanchions that are clear of the gun and that support a life line and weather cloth. The plating may be perforated or scuppers fitted. Wood should not be used on this platform, because it splinters and is inflammable. If the adjacent parts of the ship are wood, then wood may be used, because the evil of splintering wood, etc., cannot be avoided entirely.

To the rear of the gun the platform should be widened out to provide space for a ready service ammunition box and an observation station for a couple of men. The ready service box is a watertight wooden or metal box having a hinged top and front big enough to hold a dozen to two dozen shells. Such a box for a 5-inch gun is about 5 by 2½ feet and 4 feet deep. The observation platform has a pipe rail and high stanchions supporting a substantial weather cloth.

The platform should be readily accessible by a companion or ladder located at the rear of the gun, and all deck fittings, such as boat davits, ventilator cowls, etc., should be portable, so that when it comes time to shoot there will be nothing permanent in the way.

Magazines and Gun-Crew's Quarters

A magazine below the water line will be required. Two small ones near each gun or one large one will do. Two hundred rounds to a gun or four hundred rounds for both guns is none too much if some of the reports are true that these boats often run out of ammunition blazing away at a submarine. Locate the magazine aft if possible. Make a watertight compartment out of it, or if of wood, build it clear of the decks and bulkheads, well braced and sheathed with galvanized sheet iron. Provide a strong, tight door. Don't put any light in the magazine, but arrange them outside to shine in through light boxes or in through the door when it is open.

This magazine should be ventilated and provided with a flooding connection, 2 inches diameter, from a fire main.

The ammunition is hoisted up to the platform by a small davit and a block and tackle. The means of getting it out of the magazine depend upon the location of the magazine. Don't forget that sometimes the simplest and best way is for a man to pick it up and carry it.

First class quarters must be provided for the gun crew. There is a commanding officer, who can be nicely located in the spare stateroom. Two petty officers have another room, and the crew (7 men for a 5-inch gun) have to be berthed and messed separately from the ship's crew. An additional and separate lifeboat must be provided for the gun crew.

There are other things to be looked out for, such as alarm bells, telephones, etc., but these can be taken care of when the gun representative lands on the job. He knows his busines and is particular enough to have everything properly installed.

Good luck, Casey! MAC.

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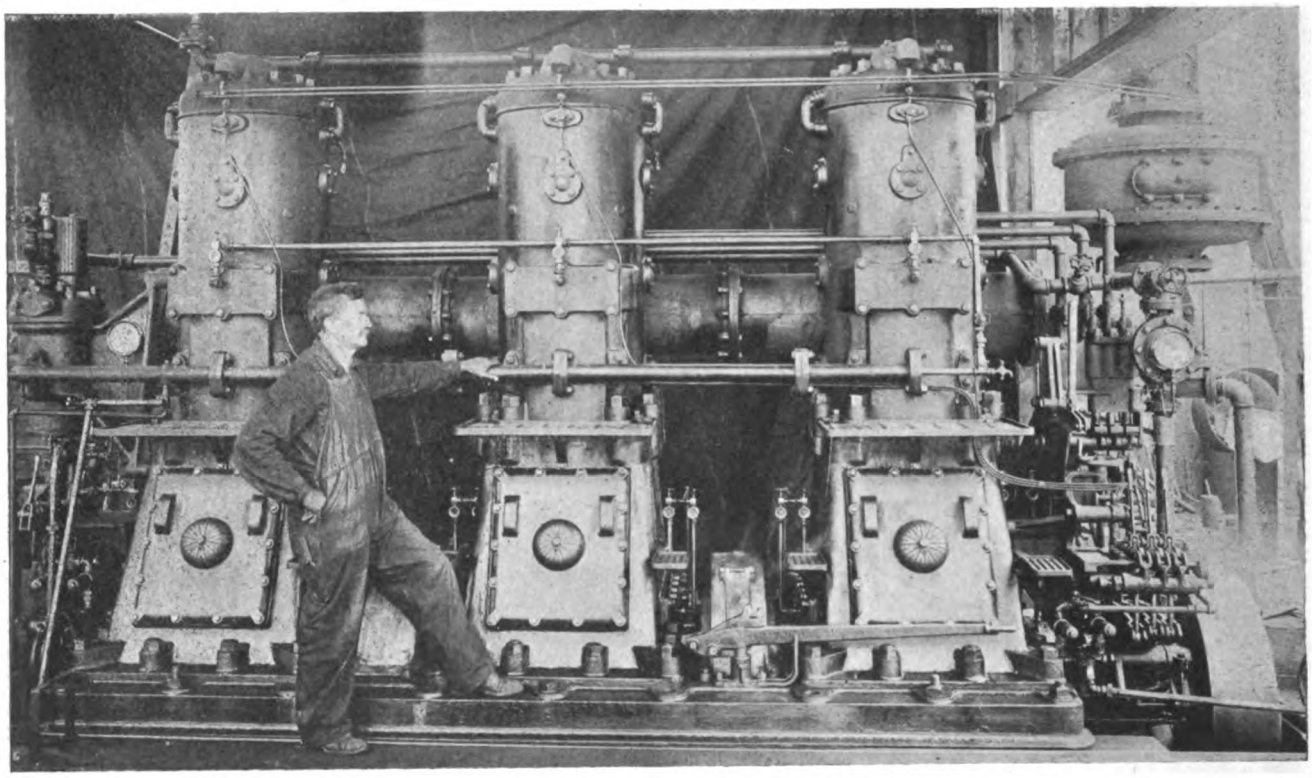

Three-Cylinder, 250-Horsepower Engine; Cylinders, 16 Inches Diameter by 24 Inches Stroke; Piston Speed, 720 Feet per Minute

Direct Reversible Marine Oil Engine

Three-Cylinder Type of from 75 to 500 Brake Horsepower Built by Seattle Machine Works, Seattle, Wash.

A NEW type, direct reversible marine oil engine has just been completed at the Lander street plant of the Seattle Machine Works, Seattle, Wash. The designer, Mr. Carl Engel, who was engaged by the Seattle Machine Works about a year ago, has been actively engaged in internal combustion engine construction for over nineteen years, and his practical experience in that line as superintendent in a large Eastern manufacturing plant has made it possible for him to work out an entirely new design of engine, not only eliminating all unnecessary complicated parts, but also embodying new improvements which are important to a successful running oil engine. It has been the designer's endeavor to build a simple, accessible and easily operated engine, made fool proof; with liberal strength and dimensions, and constructed to stand up under all conditions. It operates on fuel oil or any oil that is suitable for oil engines. It is direct reversible with compressed air. The reversing mechanism is a new invention (patent on which has been applied for), and has already been installed by the Seattle Machine Works on several Eastern engines. This company now has orders for four more reverse mechanism installations.

The engine has three cylinders, each 16 inches diameter by 24 inches stroke. The castings for cylinders and pistons are made of a special mixture of close-grained cast iron. The cylinders and cylinder-heads are tested separately under hydraulic pressure. All openings on the cylinder or crank case are covered with flanges and are placed in such a position that these can be readily removed without trouble. The cylinders are water jacketed and have ample water circulation from a pump, which is operated from the main shaft.

Crank Bed Plate

The crank bed plate is cast in one piece and is constructed to take care of the crank shaft and bearings in itself so that the whole top of the engine can be easily removed without disturbing the shaft or main bearings. The strength and construction of the crank bed plate make it almost impossible to draw same out of line and cause hot bearings. It has, furthermore, sufficient rigidity to eliminate any possibility of its working loose from its foundations providing these are made in proportion to the size and strength of the crank bed plate.

The crank shafts are made out of high-carbon, open-hearth steel, and are made over-size to Lloyds' requirements.

The dimensions of crank pins and main bearings are such as to obtain a very large bearing surface so that the pressure per square inch is low enough to keep the bearings cool under any load which the engine may carry.

Cylinders Have Individual Fuel Pumps

Each cylinder has an individual fuel oil pump of the simple plunger type with self-contained ball checks. The centrifugal force of the governor weights is impacted to the sliding device which is connected to all the rocking bell cranks for the fuel injection pump. This is operated by eccentrics on the main shaft, on which the sliding de-

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vice is working in such a manner as to cause a long or short stroke of the injection pump. According to the load the displacement of fuel is in direct proportion to this variable stroke.

GOVERNOR

The governor, of the centrifugal balanced type, is not affected by the rolling of the ship. It is driven directly from the main shaft and in conjunction with the plunger of each pump through the sliding arrangement before mentioned regulates the amount of oil injected according to speed and load of the engine. In any case of emergency in which the loss of a propeller or the breaking of the shaft would speed up the engine a few revolutions above its normal speed the increased centrifugal force on the governor weights will stop the engine and thus avoid more damage.

The Engel air distributing valve with which this engine is equipped can also be attached to any marine oil engine for direct reversible purposes. The valves are in motion only when starting and reversing the engine so that there is no wear on any part connected with them while the engine is in operation. The same eccentrics which operate the fuel injection pump also operate the air-distributing valves.

REVERSING MECHANISM

When the reversing lever is pushed out of its neutral position in either direction it will immediately shorten the stroke of the injection pump and at the same time the air distributor will start to open according to the time set for each cylinder, which will receive the full volume of air required for the engine. When the lever is put back to the center of the quadrant the oil injection pump will resume its full stroke, and the engine will take the full amount of fuel oil required according to the speed and load as regulated by the governor.

This engine has no lubricator or force feeder requiring a lot of copper tubes leading to the cylinders, bearings and other working parts such as are usual on other oil engines. The lubricating system is very simple in construction. A plunger type pump, which is always in operation with the engine, takes care of the lubricating oil, which is forced through a pipe and remains under a certain pressure against sight feed valves, which are attached to all the main bearings. The pressure of the lubricating oil is regulated by a by-pass valve according to the amount of oil required for each bearing, and is indicated by a gage.

METHOD OF LUBRICATION

There are no lubricating oil pipes attached to the cylinders, as the piston itself carries the oil required for its own lubrication. Crank pin, wrist pin, cylinder and piston receive their lubricating oil through a plunger pump attached to the inner wall of each crank case, and this also is regulated by a single sight feed valve which is connected with the same pipe from which all the other bearings receive their oil. In addition to this lubricating arrangement a small hand pump is attached close to the other oil pump, which can be used immediately in case of emergency or when oil is required before starting the engine. It is also of great advantage to the operator or attendants and does away with oil cans, which are often not at hand in time of need. This plunger type oil pump takes the oil directly from the main oil storage tank.

The inclosure of the crank case does away with all danger to inexperienced attendants. The rigidity of the main crank shaft bearings and the slightest leakage past the piston, which is often noticeable in open crank cases, has been entirely and permanently overcome on this engine, it is claimed, by passing a charge of pure air unmixed with fuel oil through disk valves into the crank case. This air is compressed by the downward stroke of the piston, which allows it to pass into the combustion space.

In order to prove complete and perfect assembling and developing of power as rated, a test has been made covering a period of approximately three months. The fuel oil consumption shows at a brake test of 250 horsepower, with a speed of 180 revolutions per minute, seven-tenths of a pound per horsepower per hour. During the test the engine was subjected to an overload of 15 percent, the 16-inch bore by 24-inch stroke giving a piston speed of 720 feet per minute.

This type of engine is built in units of from 75 to 500 brake horsepower.

Use and Care of Pneumatic Tools for Shipyards

BY GLENN B. HARRIS

PERHAPS in no other branch of the metal industry have pneumatic tools proven of greater value than in the shipyards of the country engaged in the building of steel ships.

The chipping hammer has proven of incalculable benefit in all chipping operations, and of equal value in calking. In the latter operation it is, of course, used on all side and deck seams as well as on bulkheads and tanks, and its gain over hand work is probably three to one, while the character of the work performed by it is superior to that done by hand, inasmuch as the blow delivered by the pneumatic hammer is always of a uniform character, due to a practically constant pressure, while it is said that the work of a man by hand is not so marked, owing probably to the fact that he is fresh and vigorous in the morning, and wanes in strength as the day progresses. Calking by machine, even when subjected to high pressure, seldom shows a "sweat." In the boiler shops of shipyards it is also utilized to the same advantage.

In chipping, the pneumatic hammer is utilized for all operations of that character, and, as is well known, there are many of them required in ship construction. Unique uses to which the hammer has been put are many and varied. It is utilized to cut and finish up patch bolts on the eye of a propeller; in making up patch plates on boss and propeller eye, in cutting out hawse holes, and work for which the hand hammer or mallet is ordinarily adapted. The chipping hammer unquestionably does the work of at least three men by hand.

In an amplified form the pneumatic hammer has proven also to be of the greatest benefit to the shipbuilding industry. Reference in this connection is here made to the riveting hammer. The riveting hammer is simply the chipping and calking hammer in enlarged size. The piston diameter is not materially increased, but the length of stroke is extended from that of the chipping hammer, which is about 2 inches or 3 inches to 6 inches, 8 inches or 9 inches.

The hammer as originally introduced for shipyard work was mounted in various devices for ship riveting. There was a special machine for driving flush deck rivets, which consisted of a heavy, cumbersome frame carrying a pneumatic hammer of extraordinary proportions. This machine did the deck riveting, and a man with a chipping hammer cut off the head, after which in some instances the rivet was driven further into place, although unnecessary, except for the purpose, perhaps, of smoothing down. This was an absolutely unnecessary proposition, as the ordinary pneumatic hand hammer would perform the work with greater efficiency and in less time.

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In the case of outside or shell riveting an apparatus was provided for holding the riveting hammer. This has since been dispensed with and the usual type of riveting hammer employed to take its place.

The riveting hammer has worked a revolution in the construction of steel ships, not only permitting their construction in a short period of time, but lessening materially the cost of production.

An ingenious device which is a modification of the pneumatic hammer is utilized for packing condenser tubes. A leaky condenser on board ship causes a great deal of trouble and it is claimed that the cause of leakage in a great many instances can be directly traced to the fact that the packing laces are not carefully laid in. Twelve to eighteen tube ends can be packed per minute, and experts have exceeded this number in the same length of time. As with the calking and chipping hammer the work of the packing tool is of a uniform character, and each tube is packed precisely like its neighbor. The machine is light and easily handled, and is undoubtedly of value for the purpose for which it was designed.

The air drill is of equally great saving in the shipyard, as is the pneumatic hammer, and the uses to which it is put are varied and numerous. In addition to all drilling operations requisite in ship construction, this conveniently portable machine is used to greater advantage in reaming operations, for boring in wood and different grinding operations. What is known as a close corner drill is also marketed and is of particular use and has been almost universally adopted in shipbuilding for rolling the outer tier of flues in boilers; also for tapping and other work in close quarters. The pneumatic drill is also used to great advantage in drilling out rivets in the shells of ships. Various new uses are continually suggesting themselves for the employment of this tool, and they all make for economy in production.

Proper Handling of Pneumatic Tools

In most yards the workmen handling pneumatic tools are not mechanics, and the machines require careful handling to obtain the best results. This is hardly to be expected of unskilled labor. Like all other classes of machinery, these devices must receive proper lubrication to insure the best results, and this, with their proper cleaning, is most essential.

The writer, from a long experience in this line, knows full well that the material used in all these tools is the best obtainable. There have been long periods of experiment to get what will stand the wear and tear to which they are subjected. The moving parts in both the hammers and drills are accurately and closely fitted, and when proper lubrication is neglected these fine pieces of machinery wear rapidly and in a very short time refuse to work.

As the air which is taken into the compressor generally contains some particles of grit and dust, the working parts of the hammer and drill are likely to become clogged with this foreign matter, causing the ports to become closed and the tools rendered inoperative. The use of a poor grade or heavy-bodied oil will also cause the same trouble. The best plan to follow in a case of this kind is to cleanse by introducing gasoline (petrol) in the air induction. This will dislodge any extraneous matter and cuts the thick oil, both of which can then be removed by blowing air through the hammer.

Another great source of trouble and annoyance is sometimes located in the pipe line. Moisture in the air will rust the pipes through which it is conveyed, and if the tools are connected up without first blowing out the pipes a sediment is likely to be blown through into the tool, causing valves or pistons to stick. Rubber deteriorates rapidly and dislodged particles may blow through into the tool and render it inoperative.

It frequently occurs that a workman will make complaint that his hammer or drill is not working properly, or that it will not run at all. In a great many of these cases, on the machine going to the tool room, it is found that sediment or pieces of rubber were at the bottom of all the trouble, and when cleaned with gasoline (petrol) and oiled they would work perfectly.

In a great many of the plants of this country a special tank is provided, in which the tools are immersed at night, then blown out in the morning and thoroughly oiled with the best grade of light machinery oil obtainable. This will not only greatly prolong the life of the tool, but much superior results will be obtained in all ways. It is also a wise plan to make use of a strainer at the induction end of the tool. It is remarkable what an accumulation of grit and dirt will be gathered in a short space of time under the usual conditions in a shipyard.

Harmfulness of Short Pistons

One of the most flagrant abuses to which the pneumatic riveting hammer is subjected is the use of short pistons. The riveting hammer was designed with all its parts properly proportioned to meet the requirements of various classes of work for which these tools are adapted. The workmen have discovered, however, that a piston reduced from the standard of 4 inches in length to 2½ inches delivers a more rapid blow and for a time performs faster work and with greater ease of holding. Short pistons, however, not having the body of metal in them, are subject to crumbling, due to the hard work to which they are subjected. The small, broken parts cut the cylinder, and if the latter is not damaged beyond repair from this cause it is only a question of a short time before the hammer is irreparably ruined.

When cylinders are cracked and handles and rivet sets broken the hammers should be examined to determine whether the workmen have in service a short piston. They have devious ways of obtaining them. The only sure way to determine whether a short piston has been substituted for the proper one is to have them examined while in service, as it has been found that the workmen carry the short pistons with them, make an exchange after taking the hammer out of the tool room and then replace the proper piston at the end of the day, when the tool is returned to its proper quarters.

Another abuse of pneumatic tools is the taking of them apart and the putting of them together again. Some repairmen, instead of using a wrench or soft hammer in loosening or tightening the handle of a riveting or chipping hammer, will employ a hard hammer, badly battering the parts and sometimes breaking them. The finished parts should never be struck with anything but a lead or copper hammer, and even when this is done care should be used not to unnecessarily strain the threads between the cylinder and handle.

It will pay any shipbuilding plant to employ a man who is competent to look after the pneumatic tools and see that they are properly cleaned and lubricated. In cold weather it is a wise proposition to warm up the tool. This can be done at the rivet forge. With the blow of the piston in the riveting hammer on the set when the parts are cold breakage is likely to occur. In some yards with which the writer is acquainted it is a practice to offer a premium to the workman taking good care of his tool. This should result in a saving to users of pneumatic appliances of all kinds.

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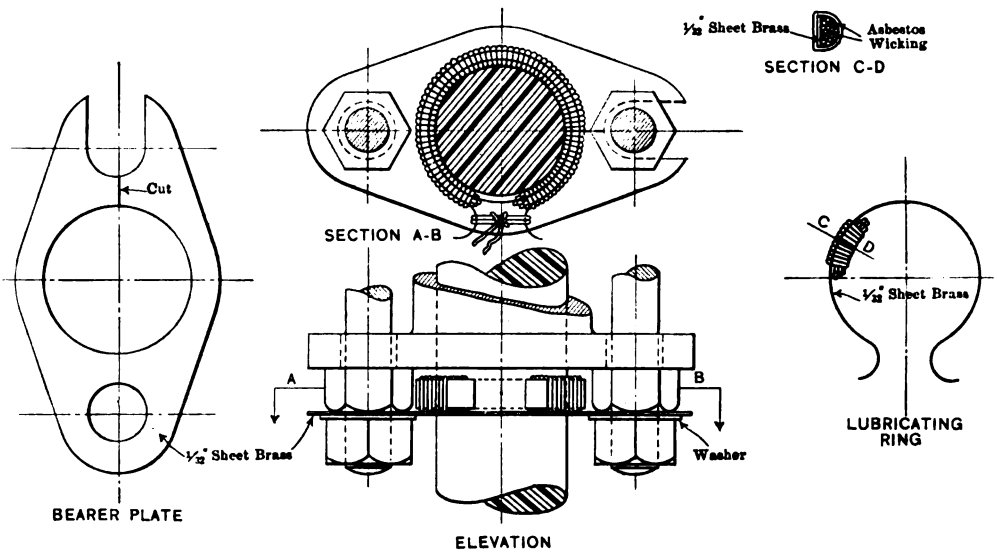
Letters from Marine Engineers

Discussion of the Design and Handling of Marine Engines, Boilers and Auxiliaries—Breakdowns at Sea and Repairs

This department is open to all readers of the magazine for the discussion of affairs in the engine room. All letters published are paid for at regular rates. Your ideas or experiences will be mutually helpful and interesting to other engineers. Write your letter now.

Lubricator for Piston Rods

The sketches shown herewith illustrate a lubricator for piston rods, which gives perfect results and which is very simply made, attached and operated. In sixteen years' experience as an engineer the writer has never seen this type of lubricator used by others. It will not only lubricate the piston rod, but it will supply an economical amount of lubrication to the cylinder walls, which is a unique feature and one which is very useful in systems using a hot-well.



Details of Efficient Lubricator for Piston Rods

One good swabbing every four or eight hours is sufficient, as the asbestos wicking holds the oil and feeds it to the rod as needed. J. F. KNOBLAUCH,

First Assistant Engineer, S. S. *W. C. Teagle.*

Baton Rouge, La.

A Visitor

Confidence in one's own ability is a valuable asset when not allowed to be over-developed. By this the writer means that one should never get to the stage where he feels that he is not susceptible to receiving advice from the older men in the business. Willingness to listen to a retired veteran chief of marine service, who was crossing the Atlantic on board the ship on which I was serving as chief, gave me some very valuable information that helped me later on in obtaining a berth with more pay and added attractions.

The veteran chief was trained in service and had practically little textbook learning, yet he was plainly a man of keen executive qualities, and some of the advice given to me in regard to handling the human factor of marine engineering proved that he had been a close student on this phase of the profession.

The seven-day trip gave us many hours together, and to listen to his conversation was practically a seven-day course of lectures by a professor of practical marine engineering. Every question and problem that I could ask or advance he quickly stripped bare of its unessentials. Everything was discussed in practical man's talk, and in an entertaining way. He was indeed an exceptional fellow, for he took a keen pleasure in imparting his ideas, convictions and experience to others who might be helped by them.

I have felt that there is need of a word being said to some of the value of cultivating the willingness to listen to the suggestions and ideas of both the old men of the profession, and from your fellow engineers. This need is more vital to the young engineer. Let no enthusiastic, ambitious young engineer make little, or undervalue the lessons or value of experience that can be gleaned from an old engineer who may by chance want to talk to you of some of his younger days in the field. Polite and willing attention to what he may have to say need not obligate you to accept his conclusions, unless they coincide with facts and reasonable deductions therefrom.

Another thing that should be borne in mind is the fact that seldom are two different marine power plants identical, even though they may be on sister ships, and that practice which may apply to one may not apply to the other, therefore there may be good grounds for differences of opinion.

It is these personal contacts with old engineers of broad experience wherein lies a valuable source of information to anyone anxious to profit by such opportunities. The facts are all gathered on the first hand, as the result of personal experience, and in getting them this way there is generally some small bit of personality interwoven that always helps to deepen the impression, and when the time of need for its recall to mind is present it makes the remembrance more ready. C. H. WILLEY.

Concord, N. H.

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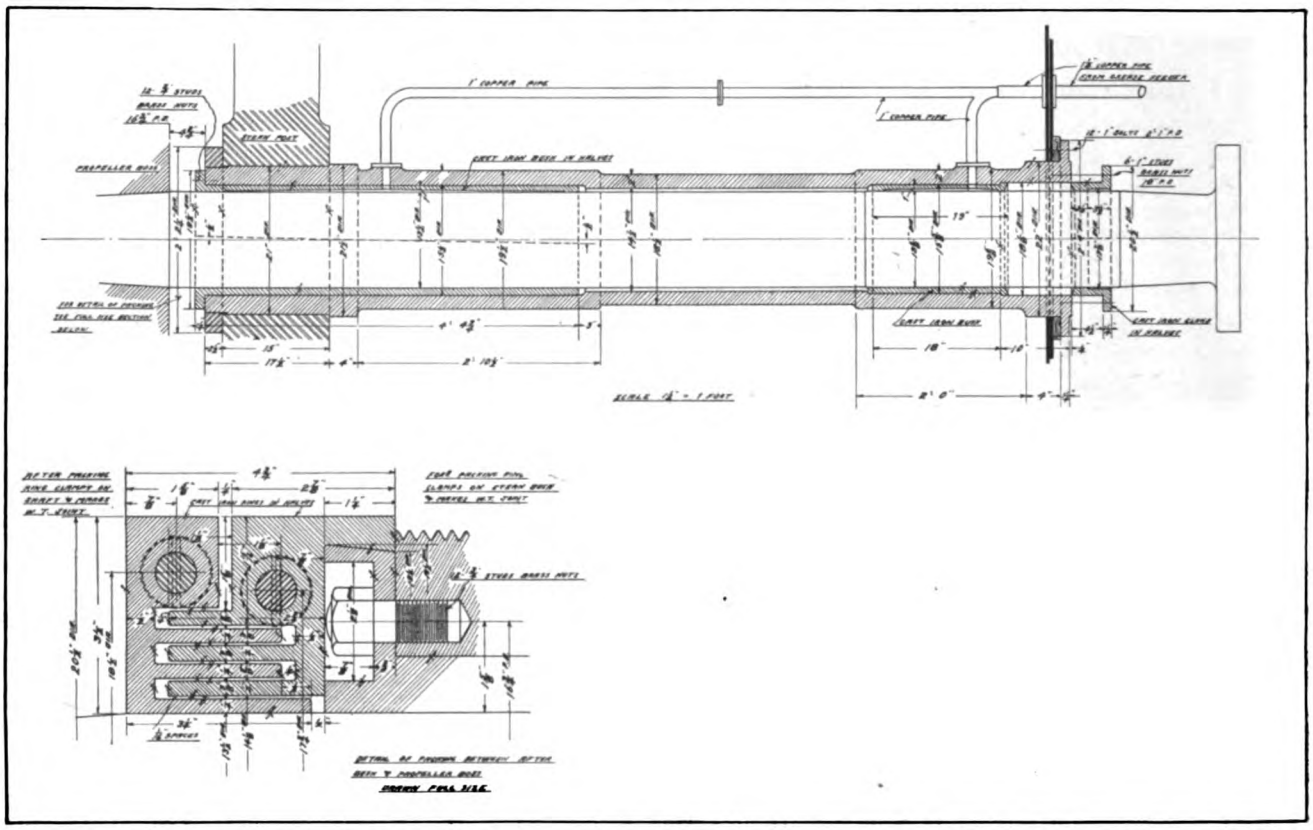
New Design of Stern Tube

A stern tube with its brass bushes lined with lignum-vitæ and its shaft cased its full length with a brass liner is undoubtedly a fine piece of work. But in these times of stress are we justified in using such a highly refined job? And besides, is this refinement necessary?

The illustration shows a tube and shaft designed to eliminate all brass parts except stud nuts. The shaft has, of course, the proper allowance in diameter as required by Lloyd's rules for shafts without a continuous brass liner, viz., 21/20ths of the diameter with a continuous liner.



Stern Tube and Tail Shaft Without Brass Bushes or Liners for Triple-Expansion Engines With Cylinders 24 Inches, 38 Inches, 62 Inches by 42 Inches Working at 180 Pounds Pressure

The shaft which this one would replace is 12 13/16 inches in diameter. It will be seen, therefore, that the increase is less than ¾ inch. As no brass liner has to be provided, a smaller outside diameter of stern tube is possible. The weight of the forging for the shaft will be slightly increased; but the shaft, ready to install, will be lighter. The tube, being smaller, will also be lighter.

The regular design of stern tube allows the sea water access to the interior of the tube and relies on the brass liner for protection from corrosion. How many shafts have been ruined because of a defective joint between sections of the liner, or between the liner and the propeller boss? The shaft shown is arranged to run in cast iron bushes, the length of which is such that bearing pressure is very light and wear will be exceedingly small.

Lubrication is provided for by a feeder operated by an eccentric on the tunnel shafting, forcing grease into the tube. The only way out for the grease is at the after end, and, as the recess of the tube would be filled before the shaft is inserted, entrance of water to the tube is prevented.

The labyrinth packing between the after end of the tube and the forward side of the boss makes a watertight joint at both the tube and the boss. The grease working out the labyrinth passage will keep the water away from the shaft. Other styles of packing could be used; for instance, a pair of overlapping rings, forced apart by springs, one fixed to the tube and the other arranged to rotate with it, but allowed fore and aft motion to bring it against a bearing surface on the forward side of the boss.

Grease cups for lubricating a pair of tail shafts running in cast iron bushes were installed by the writer some years ago and the shafts are still in excellent condition, with no signs of the water having got to the shafts.

New Westminster, B. C. A. F. MENZIES,
Mechanical Engineer.

Harmony

In the planning of shop work there are many propositions upon which different men do not agree or think along the same lines, especially when the particular plan did not originate in their minds. Right here is a time when a fellow unwittingly shows his real make-up by his unwillingness to co-operate with the other fellow in working out the scheme. When a problem develops upon which two men think entirely different methods should be used, and both cannot have their way, it should be settled on an arbitrary basis, placing the interests of the business and harmony of the organization above personal desires for satisfaction of having one's own way.

Too many times do we witness the display of ill feeling by the defeated or disappointed one, as he ignores his duty in the whole plan, and deliberately evades assistance in working it through in the manner decided upon. But, if even by chance, he is obliged by necessity to take hold and aid in the work, he does so doggedly and half-heart-

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edly, and really in his own heart hopes that the plan will be a failure—just because his was not used instead. Such a man is a detriment to any organization, even though he may be a skillful mechanic or a competent man at his work.

No man should allow his personal feelings to dominate his better judgment. There should not be a question of the moral right or wrong—it should always be rather a decision of the best interest of the shop's business.

How much more inspiring and pleasing it is to watch the other kind of a fellow, who co-operates with the plan decided upon, and does his very best to push it through to a successful conclusion. He must and does realize a personal feeling of satisfaction, even though he had to lay aside his own idea or plan in order to help the other fellow to succeed. It goes without saying that such a man is a valuable asset to the organization.

SUPERINTENDENT.

Crank Pin Repair

While on watch one night I observed the low pressure crank pin move down when on the top center and move up when on the bottom center. Not wishing to disturb the engine-room staff, I decided to keep it under close observation to make sure before taking any drastic action.

After satisfying myself that things were as they should not be, I decided to call the chief. After he arrived in the engine room and had had a look at the crank pin he decided not to take any action until we were nearer port. He consulted with the captain, however, and they agreed to run the engines at half speed and to make for the nearest port.

After two more days' steaming we arrived at port, and the third engineer and myself, with some of the firemen, began dismantling the low pressure engine by disconnecting the connecting rod from the crank pin while the chief and the second went ashore to secure the necessary gear. It was decided to carry out the repair in the following manner:

Our chief was fortunate in securing four good, strong ratchets, and we commenced drilling a series of holes half in the crank pin and half in the web. On the forward

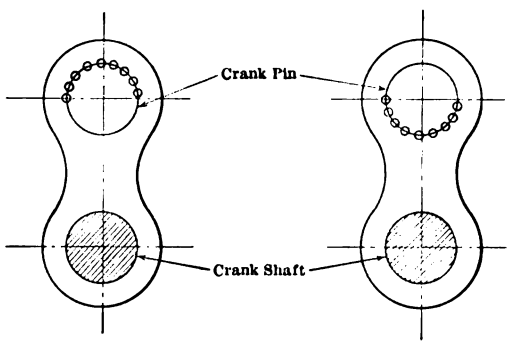

Fig. 1 Fig. 2

side of the crank we drilled the holes on the top side of the crank pin and on the after side we drilled the holes on the bottom side of the crank pin. We commenced drilling with a ⅞-inch twist drill, and after drilling to a depth of 4 inches we next started with a 1¼-inch twist drill to the above depth, and after finishing with this size we completed the drilling with a 1⅝-inch drill.

Afterward we finished reaming out the holes so as to have a smooth finished hole to be ready for the dowel pins, which the chief had ordered from a repair shop near by. The pins were made a good driving fit, and, after giving them a good coating of oil and a few friendly taps with our Monday hammer, they were soon driven home.

The connecting rod was coupled up and soon all was got ready for a trial, which, under easy steam, was a success. It was decided, however, to keep going under easy steam for a couple of days, and, after the expiration of that time, we stopped and had an inspection, and were delighted to find our job a success.

Figs. 1 and 2 will explain the arrangement of the dowel pins. The reason why we put the pins on the top side of crank pin on the forward side and on the bottom side on the after side was to prevent any undue strain on the crank pin. By driving the pins well home they have the tendency to swell the crank pin out against the web, thus making it a good, tight job.

ANDREW LAN.

Enfield, Sydney, N. S. W.

Shaft Repair

The shaft of one of our blower engines broke between the fan casing and the engine bearing. To remove this shaft and make repairs would have required disabling the blower for several days, and to make any temporary repairs seemed almost out of the question, but, luckily, one of our engineers saved the day by his resourcefulness. Figs. 1 and 2 show the manner in which a clever repair was made.

With the aid of an air hammer and chisel, the shaft was dressed up at the break, as shown in Fig. 1. Two

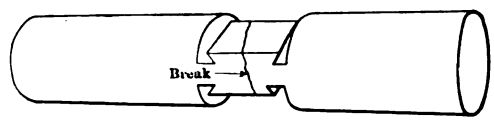

Fig. 1.—Broken Shaft Dressed, Ready for Babbit Coupling

flats were made to take care of the driving torque, while the dovetails, cut as shown, kept the break from separating; in other words, these acted as anchors. After the shaft was dressed as mentioned, a mold was made around

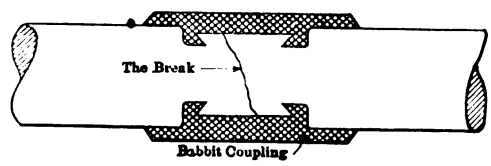

Fig. 2.—Section Through Babbit Coupling

it out of sheet tin to form the babbit coupling. The completed job is shown in Fig. 2.

This, while being a unique repair, has given very satisfactory service, for the babbit coupling was reinforced by forming up a circular sheet steel band, not shown in the sketch. The machine is still doing service today. It is thought by the writer that this repair will be found handy to others.

MACHINIST'S MATE.

CORRECTION.—In the article, "Notes on Rudders," page 445 of our October issue, equation (1), which reads

$$P = 1.622 \frac{\sin\theta}{0.39 + 0.61 \sin\theta} - \frac{w}{2g} A V^2$$

should read as follows:

$$P = 1.622 \frac{\sin\theta}{0.39 + 0.61 \sin\theta} \times \frac{w}{2g} A V^2$$

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Questions and Answers for Marine Engineers

Inquiries of General Interest Regarding Marine Engineering and Shipbuilding will be Answered in this Department

CONDUCTED BY H. A. EVERETT *

This department is maintained for the service of practical marine engineers, draftsmen and shipbuilders. All inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given permission to do so. Indicator cards taken from marine engines will be carefully analyzed, the defects pointed out and the horsepower calculated, provided complete data are sent with cards.

Relative Efficiency of Engines

Q. (917).—The following question was offered on a recent college examination paper. Will you please work out the solution for me?

"Three triple expansion engines designed for 150 pounds throttle pressure and 2 pounds back pressure are of identical dimensions and construction. One was purchased by 'A' and installed to operate with steam 2 percent priming at a throttle pressure of 200 pounds and a back pressure of 21 pounds. Actual tests showed that it had a steam consumption of 14.8 pounds per indicated horsepower per hour.

"The second engine was purchased by 'B,' installed to operate between 100 pounds throttle and 1½-inch back pressure with steam dry saturated at the throttle. The actual steam consumption was 15.0 pounds.

"The third one was purchased by 'C,' operated at 140 pounds throttle with 40 degrees superheat and a back pressure of 2 pounds. Its measured steam consumption was 14.6 pounds.

"Which man got the best engine?

"Which man got the poorest engine?

"How much better was the best than the poorest? Express in percentage."

A. (917).—The amount which each engine produces as a percentage of that possible is given by the ratio of

$$\frac{\text{Ideal (Rankine Cycle) steam consumption}}{\text{Actual steam consumption}}$$

sometimes called the commercial efficiency, and expressed as

$$\text{Commer'l efficiency} = \frac{2{,}545}{(H_1 - H_2) \times \text{actual steam consumption}}$$

where H_1 is the heat content at the admission point, H_2 is the heat content at the exhaust point, and the steam consumption is expressed in pounds per horsepower per hour.

For the three engines the commercial efficiencies are:

$$A = \frac{2{,}545}{(1{,}180 - 881) \times 14.8} = 57.6 \text{ percent.}$$

$$B = \frac{2{,}545}{(1{,}186 - 916) \times 15.0} = 62.7 \text{ percent.}$$

$$C = \frac{2{,}545}{(1{,}217 - 926) \times 14.6} = 60.0 \text{ percent.}$$

It is fair to assume that if these engines were to operate at different ranges their commercial efficiencies would not change appreciably, therefore if B were put in place of A it would produce 62.7 percent of the energy available, and therefore be better than A, which only produced 57.6 percent.

The best engine is B, the poorest engine is A, and B is better than A by

$$\frac{62.7 - 57.6}{57.6} = .089, \text{ or nearly 9 percent.}$$

The problem could also be solved by adjusting the consumption to a uniform Rankine cycle, say that of engine C, as follows:

Rankine efficiency of A (from chart published in INTERNATIONAL MARINE ENGINEERING, June, 1917) is 27.3 percent; of B, 24.7 percent; of C is 25.5 percent. Adjusting the actual steam consumptions to those of engine C, the corrected steam consumption would be:

$$A = 14.8 \times \frac{.273}{.255} = 15.85 \text{ pounds per horsepower per hour,}$$

$$B = 15.0 \times \frac{.247}{.255} = 14.55 \text{ pounds per horsepower per hour,}$$

$$C = 14.6 \times \frac{.255}{.255} = 14.6 \text{ pounds per horsepower per hour,}$$

if all worked on the same range as C. From which it will be observed that B got the best engine, A the poorest, and B's was better than A's by

$$\frac{15.85 - 14.55}{14.55} = \frac{1.3}{14.55} = .089, \text{ or about 9 percent.}$$

Strength of Boiler After Pitting

Q. (916).—I have some B. & W. boilers of the Aultman-Taylor land type which, some time ago, became rather badly pitted along the steam drums where the feed entered. The pitting was stopped, however, and has not appreciably increased in the past several years. We have been operating at 125 pounds, and now, owing to press of work, it is desirable to increase the working pressure to 150 pounds, which was what the boilers were originally designed to operate at and did operate at. The drums are of 15/32-inch plate, 42 inches diameter, 20 feet length, with two longitudinal seams, double riveted, with ⅞-inch rivets, 3-inch pitch and 2-inch back pitch (distance between rows). The pitting is pronounced and continues along the length of the drums just under the feed entrance. For the first 6 feet it is deepest and has in the worst case an average depth of somewhat less than 0.10 inch. In addition to this there are local patches of pitting at various intervals over the lower half of the drums. That first noted is the worst, however. The question has arisen as to the advisability of operating this unit at the 150-pound pressure desired. Will you please give me your opinion as to whether it is safe to do this or not?

A. (916).—If we assume that the pitting has a uniform depth of 0.10 inch and extends the entire length of the drum, the strength along this line of weakness will be about 78 percent of the strength of the intact plate. The efficiency of the riveted longitudinal seam as figured below is approximately 65 percent of the intact plate, so that the pitting has not weakened the drum to an extent greater than the weakest point of its normal structure.

It needs careful watching, however, in future use and will eventually have to be renewed.

The computations follow:

Double Riveted Seam Lap

Plate now about 15/32 inch thick.

Rivets ⅞ inch diameter, 3 inches pitch, 2 inches back pitch.

a = area of rivet, square inches.
P = pitch in inches.
t = thickness of plate, inches.
d = diameter of rivet.
S = shearing strength per square inch.

(A) Strength of intact plate = $P \times t \times 55{,}000 = 3 \times .469 \times 55{,}000 = 77{,}500$ pounds.

(B) Strength of plate between rivet holes = $(P - d)t \times 55{,}000 = 2.13 \times .469 \times 55{,}000 = 55{,}100$ pounds.

(C) Shearing strength of two rivets in single shear = $2 \times S \times a = 2 \times 42{,}000 \times .601 = 50{,}500$ pounds.

(D) Crushing strength of plate in front of two rivets = $2d \times t \times 95{,}000 = 2 \times .875 \times .469 \times 95{,}000 = 77{,}800$ pounds.

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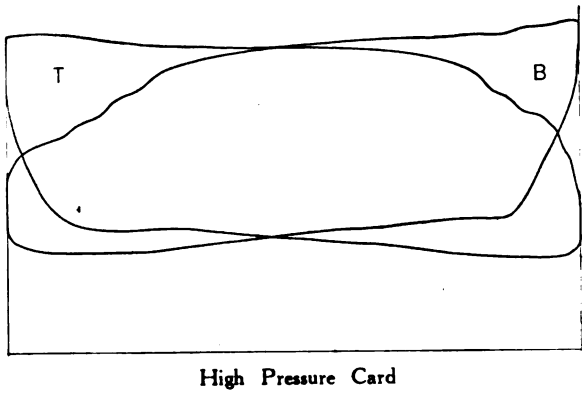
$$\text{Efficiency of riveted joint} = \frac{C}{A} = \frac{50{,}500}{77{,}500} = 65 \text{ percent.}$$

If pitting were uniform in depth of 0.10 inch, the strength along this line would be .369/.469 of the intact plate, or 78½ percent.

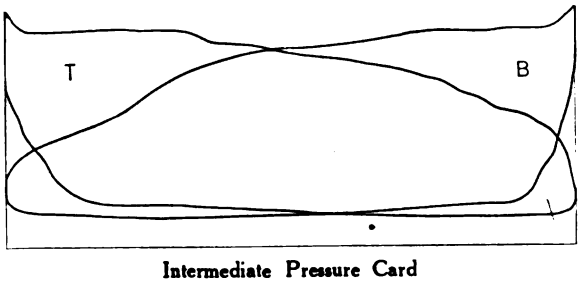
Indicator Cards Analyzed

Q. (902).—Please analyze inclosed indicator cards. Cylinder, diameters: High pressure, 12 inches; intermediate pressure, 20 inches; low pressure, 34 inches. Stroke, 24 inches. Diameter of piston rod, 3 inches. Revolutions per minute, 145.5. Boiler gage, 171 pounds; intermediate receiver gage, 57 pounds; low pressure receiver gage, 5 pounds; vacuum, 25 inches.

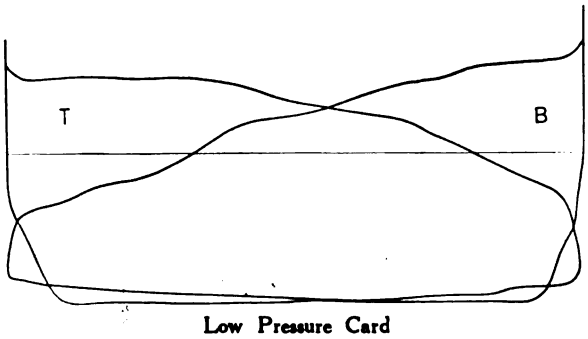
A. (902).—The detailed working up of the cards is given below. The cards themselves show room for but little improvement and the distribution of work is reasonable. There is probably little that can be gained by making any changes. A slightly better economy and distribution of effort would be obtained by operating at an increased boiler pressure (say 185 pounds) and shortening the cut-off in the high pressure cylinder.



High Pressure Card



Intermediate Pressure Card



Low Pressure Card

	Areas of Indicator Cards, Square Inches	Length of Cards, Inches	Mean Height, Inches
High Pressure:			
Top	3.81	3.5	1.088
Bottom	3.58	3.5	1.022
Intermediate Pressure:			
Top	3.14	3.49	.900
Bottom	3.10	3.49	.888
Low Pressure:			
Top	3.94	3.55	1.110
Bottom	3.65	3.55	1.028

	Mean Effective Pressure	Area Pistons, Square Inches
High Pressure:		
Top	87.04	113.1
Bottom	81.76	106.0
Intermediate Pressure:		
Top	36.00	314.2
Bottom	35.52	307.1
Low Pressure:		
Top	11.10	907.9
Bottom	10.28	900.8

Area 3-inch rod = 7.07 square inches.

$$\text{Factor} = \frac{2 \times 145.5}{33{,}000} = .008818$$

High Pressure:
Top = .008818 × 113.1 × 87.04 = 86.7
Bottom = .00882 × 106.0 × 81.76 = 76.5
Intermediate Pressure:
Top = .00882 × 314.2 × 36.00 = 99.7
Bottom = .00882 × 307.1 × 35.52 = 96.1
Low Pressure:
Top = .00882 × 907.9 × 11.10 = 88.8
Bottom = .00882 × 900.8 × 10.28 = 81.6

Total horsepower 529.4

Can Iron be Gasified?

Q. (905).—I have two questions to ask that I have heretofore been unable to have solved. (1) If it is possible to attain sufficiently high temperatures and pressures, can iron be gasified? (2) Is the center of the earth a large volume of gas?

A. (905).—The answer to question (1) is that iron has been distilled (in the gaseous state) in electric furnaces at about atmospheric pressure.

To question (2) no definite answer can be given, for nobody knows what the center of the earth consists of. Great pressure may produce liquefaction, but produces it more readily the less the temperature; the converse (gasification) is most readily obtained at high temperatures, and the less the pressure the better. For example, you can have highly superheated steam at atmospheric pressure and also can superheat steam at a high pressure, but the first condition requires less heat to produce it. If you are interested in obtaining a gaseous state from a solid state, you will accomplish it most readily at the lowest pressure at which you can operate. It should be borne in mind, however, that our ordinary conception of what constitutes a gaseous state [that the molecules are separated from each other to such an extent that they tend to increase this distance (expand) indefinitely] does not hold when pressures are so enormous as to bring the molecules close enough together to be seriously affected by mutual attractions.

Power and Revolutions of Propelling Engines on Dock Trials

Q. (918).—With a turbine engine developing 22,000 horsepower, the wheel has a pitch of 100 inches, a diameter of 9 feet 2 inches, and makes 335 revolutions per minute. What would be the revolutions per minute if the ship was made fast to the dock and not allowed to move? Would the engine develop the same or more or less power under these conditions, assuming the pressure on the steam chest to be the same as when under way.

A. (918).—The power quoted is abnormal for a single shaft and propeller of the dimensions given and is probably divided among several shafts, though the data give no hint of it. Assuming such to be the case, it is probable that in the original design the propellers were calculated so as to operate close to the point of cavitation and any large increase in tip speed or slip will undoubtedly produce cavitation. If cavitation results, the power at the same revolutions per minute will be less than in normal running. What the revolutions per minute will be for the same boiler pressure under this condition cannot be predicted, but they will be much greater. The horsepower would probably be less.

CORRECTION.—The answer to Q. (903) in the September number, page 415, relative to the movement of a valve, if the eccentric with 5-inch throw on a 15-inch shaft is moved ⅛ inch, was based on the assumption that the center of the eccentric moved ⅛ inch. In shop practice this measurement would be made on the periphery of the shaft, and since the ratio of eccentric throw to shaft diameter in this case is 1 to 3 the valve movement would be 1/24 inch and not ⅛ inch maximum, as stated.

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FIRST BRITISH STANDARDIZED CARGO SHIP

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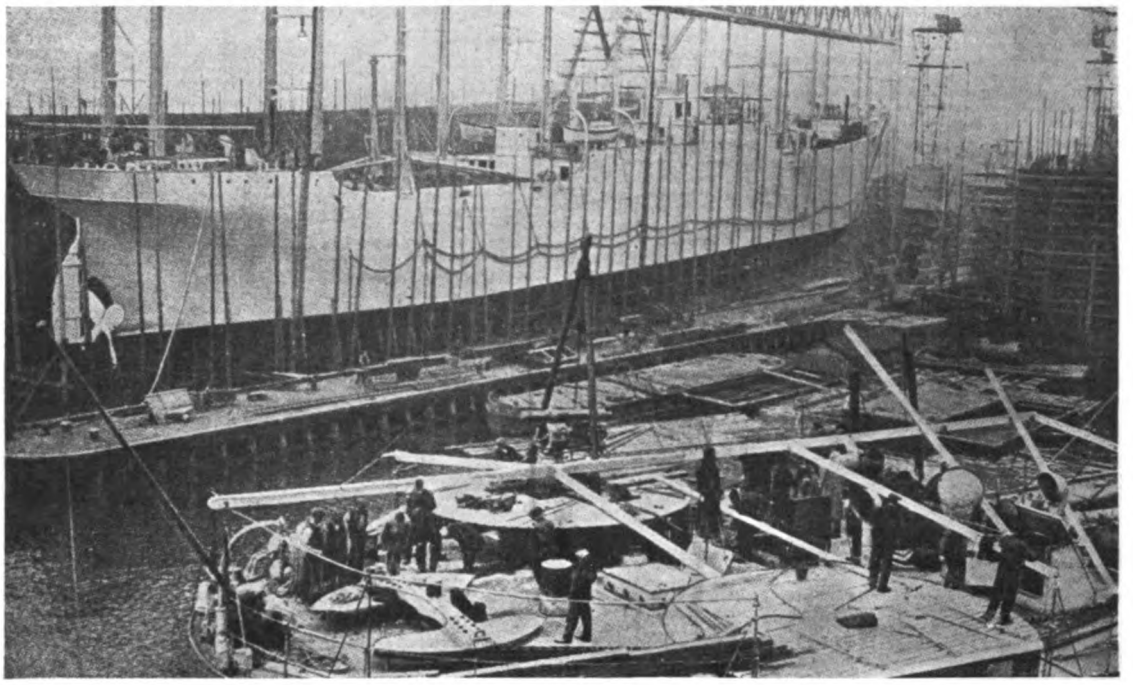

Fig. 1.—Standard Ship of 8,000 Tons Deadweight Carrying Capacity About to Be Launched, With Stern of a Sister Ship in the Foreground

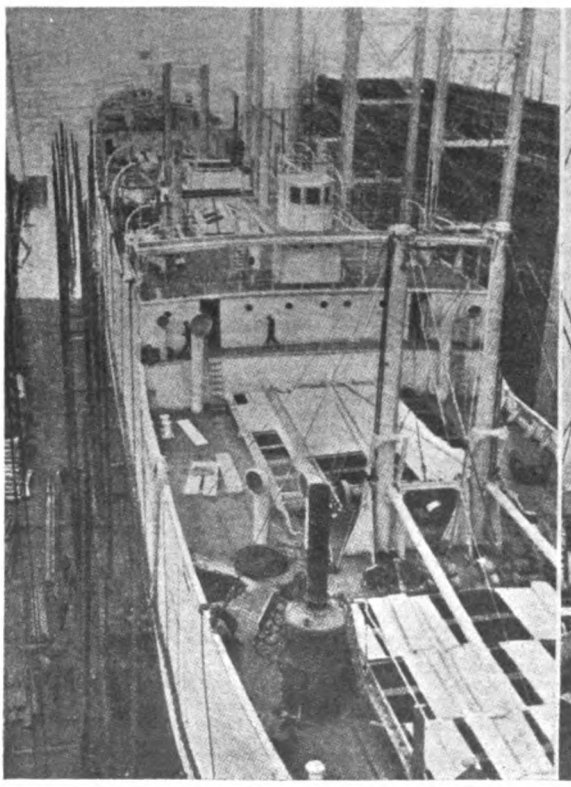

Fig. 2.—Deck View of Ship Ready for Launching

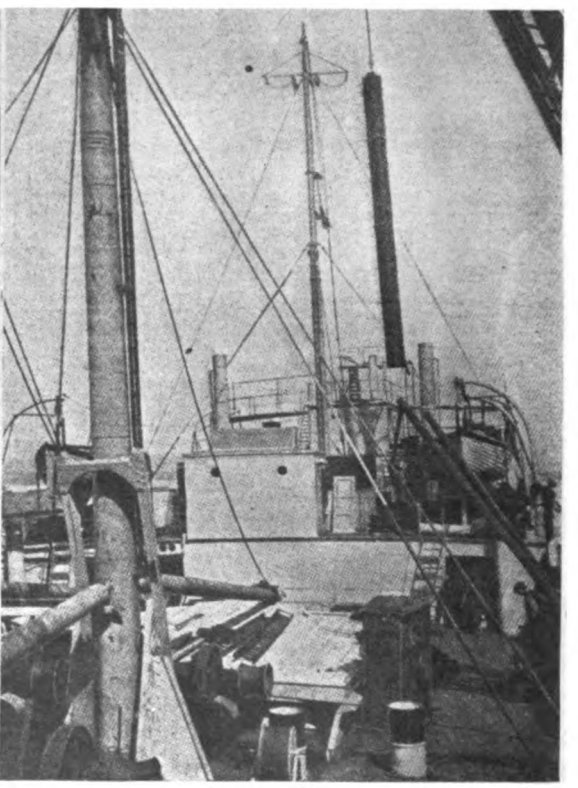

Fig. 3.—Fitting Out the Vessel for Sea Service

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Shipbuilding and General Marine News

Contracts for New Ships—Shipyard Improvements—Engineering Projects—Improved Appliances—Personal Items

BETHLEHEM STEEL SHIPYARDS CONSOLIDATED

Six of the Largest Shipyards in the United States Under Management of Bethlehem Shipbuilding Company

The Bethlehem Steel Corporation, which controls six of the largest shipyards in the United States, including the Fore River Shipbuilding Corporation, Quincy, Mass.; the Harlan & Hollingsworth Corporation, Wilmington, Del.; the Samuel L. Moore & Sons Corporation, Elizabeth, N. J.; the Union Iron Works Company, and the Union Iron Works Dry Docks Company, San Francisco, Cal., and the Bethlehem Steel Shipyard at Sparrows Point, Md., has organized the Bethlehem Shipbuilding Company, capitalized at $12,500,000, with headquarters at South Bethlehem, Pa., to have complete charge of all its shipbuilding interests.

E. G. Grace, head of the Bethlehem Steel Corporation, is president of the new shipbuilding company; Joseph W. Powell, president of the Fore River Shipbuilding Corporation, has been appointed vice-president and executive head, and H. S. Snyder, vice-president of the Bethlehem Steel Company, has been made vice-president, in charge of finances of both the shipbuilding company and the steel corporation. The other officers include H. E. Lewis, vice-president; E. B. Hill, treasurer; B. H. Jones, secretary; F. A. Shick, comptroller; William M. Tobias, purchasing agent, and J. M. Gross, general traffic manager.

Mr. Powell has taken active charge of the sales and operations of the new company at South Bethlehem, and with him are associated several other officers of the Fore River Shipbuilding Corporation, including Vice-President and General Manager H. G. Smith, Vice-President Harry Brown, Treasurer E. B. Hill, and Joseph Larkin of the service department. S. W. Wakeman, formerly general superintendent of the Fore River plant, succeeds Mr. Powell at that plant with the title of manager, and Joseph P. Kennedy, formerly president of the Columbia Trust Company, Boston, has been appointed assistant manager.

The formation of the Bethlehem Shipbuilding Company was brought about after the consultation with the Navy Department for the purpose of speeding up the construction of ships. According to the formal announcement, the demands of the Government on the facilities of the shipbuilding plants will make it essential that all duplications of engineering and similar overhead work shall be avoided so far as is possible, and the proposed consolidation is expected, through the resulting standardization and the centralization of management, to increase the production of the yards affected—a result of vital importance in this time of insistent demand for expedition in the building of ships.

There will be no radical departure from the present operating methods at the individual yards, except that the sales, purchases, accounting, collections and payments for all shipbuilding operations will hereafter be made or done at or from Bethlehem.

Pacific Coast Now Represented on the Shipping Board

Charles R. Page, the new member of the United States Shipping Board, is a son of the late Charles Page, of San Francisco, Cal. Mr. Page is a graduate of Yale University, and has been connected with the shipping industry with Hind, Rolph & Company, of San Francisco, and more recently with the Fireman's Fund Insurance Company.

Mr. Page takes the place on the Shipping Board of Mr. Theodore Brent, of New Orleans, who resigned with Mr. Denman, former chairman, and before coming to Washington made an extensive investigation of the Pacific Coast shipyards.

The Shipping Board is now composed of the following: Edward N. Hurley, Chicago, chairman; Raymond B. Stevens, New Hampshire, vice-chairman; John A. Donald, New York; Bainbridge Colby, New York, and Charles R. Page, San Francisco.

President of Munson Steamship Line Joins Exports Administrative Board

Frank C. Munson, president of the Munson Steamship Line, has been appointed a member of the Exports Administrative Board. The other members of the Board are: Vance McCormick, chairman, representing the Department of State; J. B. White, representing the Food Controller; Thomas Jones, representing the Department of Commerce, and Dr. Taylor, representing the Department of Agriculture.

For twenty-two years Mr. Munson has been connected with the Munson Line. He is also prominent in civic affairs connected with shipping interests, having been for several years on the Mayor's Port and Terminal Committee and chairman of the Brooklyn Committee on Waterfront and Terminal Railroads, a member of the board of managers of the American Bureau of Shipping and a member of the American Committee of Lloyd's Register of Shipping.

NAVAL WAR CONSTRUCTION NOW COMPRISES 787 VESSELS, TO COST ABOUT $1,150,400,000

Destroyers Form Major Part of Programme

Five Yards to Build the Additional Destroyers

The war construction programme of the United States Navy now comprises 787 vessels, including all types, from superdreadnoughts to submarine chasers. Some of these have been completed in the past few weeks and are now in service. The rest of the programme is being pushed to completion. The total cost is estimated at $1,150,400,000.

Secretary Daniels has announced that arrangements have been completed for the building of the large number of additional destroyers planned, which will cost about $350,000,000. The Secretary said:

"These destroyers will be built by five companies which have had experience in building this type—the Fore River Shipbuilding Corporation, Boston; the New York Shipbuilding Corporation, Camden, N. J.; Cramps Shipyard, Philadelphia; the Newport News Shipbuilding & Dry Dock Company, Newport News, Va., and the Union Iron Works, San Francisco.

New Plants Required

"This is the biggest project we have ever undertaken. Three months ago it looked as if it could not be done. Orders had already been given for all the destroyers the yards could build, and almost as many as the new programme calls for are now under construction or contract. To build rapidly the additional destroyers require a great extension of shipbuilding facilities and the erection of new plants for building engines. The companies were unwilling to invest millions in these additions, so the Government must build and will own the new plants and extensions which will be used by the builders.

"We are putting every energy and facility behind this project. Some of the new destroyers are promised for delivery in nine months, all within eighteen months. These vessels will be of the latest and largest improved type, which has just been tried in our service and found to be unsurpassed by any destroyers in the world.

Advantage of Uniform Type

"The plans are all ready, and the adoption of a uniform type will enable us to reduce the number of types of engines and parts and to turn them out in much less time. The principal trouble is in getting forgings and auxiliaries,

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but the manufacture of these has been arranged for, and we will make every effort to prevent delay in delivery of materials or machinery.

"Thousands of men will be required to man these destroyers, and we are now busy training them. By the time the vessels are completed the crews will be ready. The spirit of the men in the navy—officers and enlisted men—is such that the destroyer service appeals to them, and many more than enough to make up the complements apply for service in this type of ship, which is the best weapon afloat against the submarine menace."

Shipbuilders Awarded Contracts for New Vessels

A contract has been awarded to the McAteer Shipbuilding Company and the National Steel Construction Company, jointly, for the construction of a 1,200-ton deadweight steel vessel for the United States Government, the contract being awarded by the Western Division of the Quartermaster Department.

The new vessel will be 170 feet in length, with a beam of 30 feet and a molded depth of 15 feet. The contract price is said to be about $250,000.

The Francis Cobb Company, Rockland, Me., will build a 3,500-ton freight ship for the Great Northern Paper Company.

The Wilmington Shipbuilding & Marine Construction Company, Wilmington, N. C., will build two four-masted wooden auxiliary schooners from the designs of Cox & Stevens, 15 William street, New York.

The new Elliott Bay Shipbuilding Company, of Seattle, President C. O. Morrow, has signed contracts for five full-powered, ocean-going, wooden motor ships for American interests, and work will be commenced immediately, as it is intended to have the five vessels under construction in the plant at the same time. The first two vessels are for interests engaged in the salmon canning industry in Alaska, and they will operate between Seattle and the North. The other vessels are to be built for Atlantic interests. The contracts call for motor ships 260 feet long, 46 feet wide and 26 feet deep, with a cargo capacity of 3,000 tons deadweight. Each of the motor ships will be supplied with two 500 brake-horsepower Diesel engines, which it is expected will give the vessels a speed of 9 knots.

SHIPBUILDING AT JACKSONVILLE, FLA.

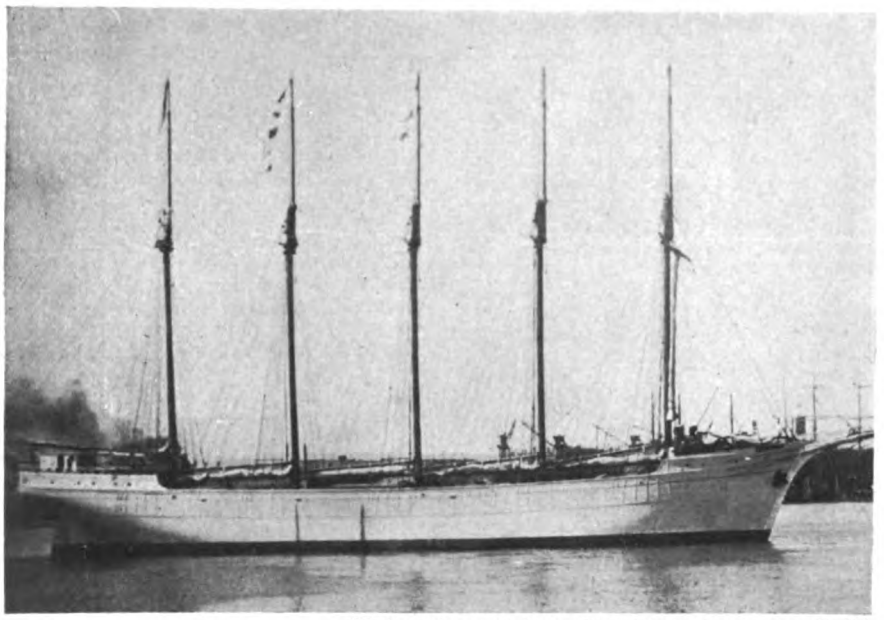
Available Water Frontage Given Over to Shipbuilding

Every available foot of ground on the Jacksonville side of the St. Johns River is now being used for the construction of ships, and much of the best water frontage on the South Jacksonville side is also occupied or held under lease by prospective shipbuilding concerns.

The new Merrill-Stevens plant, covering 60 acres of land directly across the river from the main plant, is nearing completion, and will represent an expenditure of over $500,000 before a keel is even laid. This concern dredged a slip 175 feet wide by 1,000 feet in length, and will launch their ships sidewise, as well as by stem and stern, into the river, thereby giving a capacity of twelve wooden or eight large steel or composite ships at one time.

The Government plant, formerly that of Hillyer-Sperring-Dunn, is installing a mammoth transformer, having secured electricity from the municipal electric plant of Jacksonville, and as soon as the additional machinery is ready the keels of several new vessls will be laid.

The plants now in active operation are Merrill-Stevens Company, G. S. Baxter Shipyards, Florida Shipbuilding Corporation, Gibbs Gas Engine & Shipbuilding Company, J. M. Murdock, Morey & Thomas, Florida Marine Construction Company, Hillyer-Sperring-Dunn Company (Government-operated).



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Largest Sailing Vessel on the Pacific, the *Falketind* (formerly *Flagstaff*), of 4,000 Tons Deadweight Carrying Capacity

Terry Shipbuilding Company to Build Homes for Its Employees

The Terry Shipbuilding Company, which is constructing twenty steel cargo vessels for the Emergency Fleet Corporation, to be worth $20,000,000 in all, has closed a contract with the Port Wentworth Terminal Corporation at Savannah covering the erection of dwellings for its employees. The Terminal company is to erect houses as they are needed and lease them to the Terry corporation at a rental based upon the cost of construction.

The new buildings will become part of Port Wentworth City, which is being built to provide homes for employees of the various industries located at the terminal. The Terry plant alone will have over 3,000 workers.

Marine Terminal Improvements

The New York Dock Company, 44 Whitehall street, New York, has awarded a contract for the erection of a three-story reinforced concrete building, about 53 by 153 feet, on property recently acquired on Furman street, Brooklyn.

The Great Lakes Dredge Company, Port Arthur, Ont., has been awarded the contract for the construction of wharves and slips in connection with the steel plant to be erected for the Canadian Steel Corporation, Ojibway, Ont. The Canadian Steel Corporation is a subsidiary of the United States Steel Corporation.

P. B. Church & Company, Arcade building, Seattle, Wash., has received a contract to build a dock at Duwamish Waterway.

American Shipbuilding Company's Output

At the annual meeting of the American Shipbuilding Company, of Cleveland, Ohio, recently held in Jersey City, N. J., Mr. M. E. Farr, president of the company, said:

"During the current fiscal year thirty-one ships, with a total capacity of about 161,000 gross tons, have been completed and delivered to owners. There are now forty-three ships, with a total carrying capacity of about 160,000 gross tons, under contract.

"During the year appropriations for additional buildings, equipments and other improvements amounting to $1,063,000 were authorized. There was expended $15,000 for lands adjoining the Lorain plant, and $555,778 for buildings, equipment and other improvements. These additions have materially improved the efficiency of the several plants.

"While the net earnings for the year are satisfactory, they do not represent the maximum earning capacity of your company. A considerable part of the earnings of the current year came through the early and advantageous purchase of material. The scarcity of labor and materials, unusually bad weather conditions, embargoes, rising costs and other contingencies have prevented the management from obtaining maximum results. Conditions are better than at any time in the past, and the prospects for future business are favorable."

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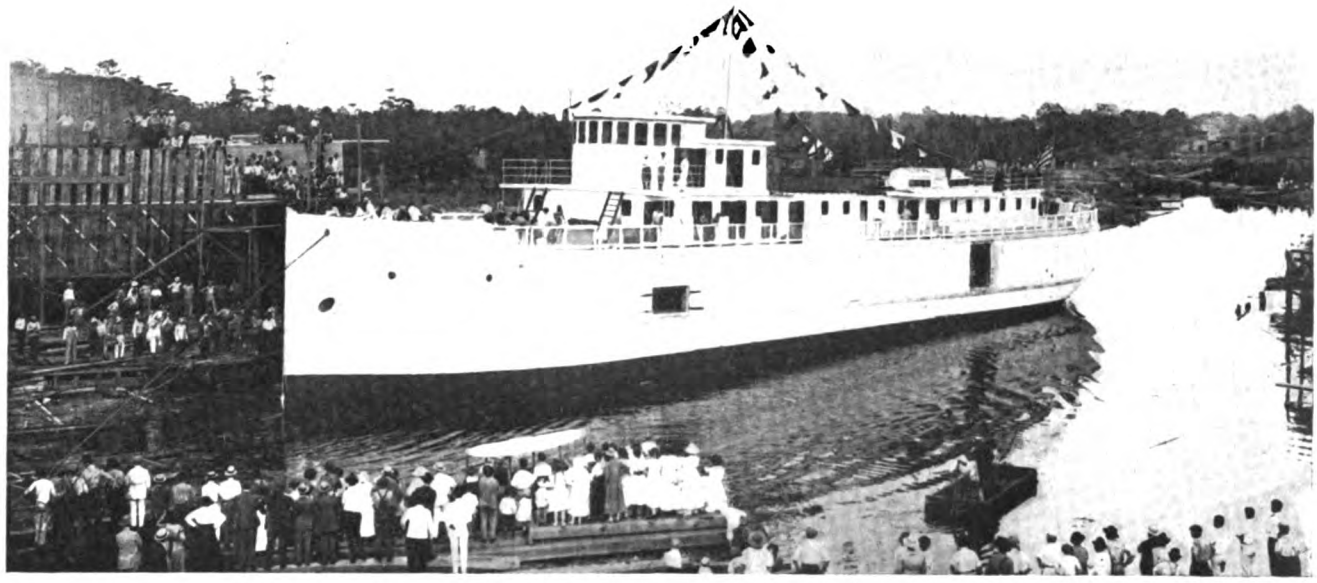

Launching of Passenger and Freight Steamer *Maple*, Built of Southern Pine at Slidell, La.

AMERICAN VESSELS OF 2,500 TONS CAPACITY OR OVER REQUISITIONED

Government Controls Ocean-Going Merchant Marine

The United States Shipping Board hereby has given notice to all owners of ships registered and enrolled under the laws of the United States that the requisition of all American steamers described below, and of which previous announcement has been made, became operative and effective on October 15, 1917, at noon.

1. The ships affected by said requisition and included therein are:

(*a*) All cargo ships able to carry not less than 2,500 tons total deadweight, including bunkers, water and stores.

(*b*) All passenger steamers of not less than 2,500 tons gross register.

2. (*a*) As to all steamers in or bound to American ports on October 15, 1917, requisition becomes effective after discharge of inward cargo and ship is put in ordinary good condition.

(*b*) As to steamers which have started to load their outward cargo requisition becomes effective at noon on October 15, 1917, and accounts as to hire and expenses will be adjusted from time steamer began to load.

3. Steamers trading to and from American ports that have sailed on their voyage prior to October 15, 1917, at noon, are to complete that voyage as promptly as possible and report for requisitioning.

4. Steamers that are occupied in trades between foreign ports shall be requisitioned as of October 15, 1917, at noon, and accounts adjusted accordingly.

5. (*a*) Owners whose steamers are operating in their regular trades are to continue the operation of their steamers for account of the Government, as they have been doing for themselves, until they receive further instructions.

(*b*) Owners whose steamers are chartered to others will apply to the Shipping Board for instructions regarding the future employment of said steamers.

(Signed) BAINBRIDGE COLBY,
Commissioner.

Coal for Neutral Vessels Regulated by the Government

The Exports Administrative Board of the United States, in formulating its policy with regard to granting bunkers to neutral vessels, are actuated solely by the desire to prevent commodities from going to border neutrals for export to Germany. At the present time the Exports Administrative Board will not permit commodities that may benefit the enemy, directly or indirectly, to be exported from this country to the border neutrals because the Board has not yet been able to elicit the information which will enable it to determine whether such commodities will so benefit the enemy; and in accordance with this policy the Board feels that consistency demands that it should not grant bunker licenses for a vessel which is bound for a border neutral and carries a cargo which may benefit the enemy, notwithstanding such cargo has originated in another country.

RESTRICTIONS ON CARGOES

In other words, although the Board has no means, and does not purpose to prevent trade between other neutrals and the border neutrals, it is, nevertheless, in a position to state that if vessels wish to use the coal of the United States they should not be permitted to apply our coal to the prosecution of a voyage which will result in supplying or assisting to supply the enemy with foodstuffs or feedstuffs or any other commodities.

GOVERNMENT PLANT FOR BUILDING FABRICATED SHIPS BEGUN IN NEW JERSEY

Submarine Boat Corporation in Active Charge of the Plant

Fabricated Ships of 5,000 Tons to Be Built

Work has begun at Port Newark Terminal, on Newark Bay, N. J., on the second large Government plant for building fabricated steel ships. The plant is being built by the Submarine Boat Corporation, which is acting as agent for the United States Emergency Fleet Corporation. The yard occupies 125 acres, twenty-eight shipbuilding ways will be built and the yard will employ 12,000 men.

The site has a water frontage of 2,700 feet where the twenty-eight shipbuilding ways will be erected. On one side of the property is a slip 700 feet wide and a wharf 4,400 feet long by 50 feet wide. The buildings now being erected include an administration building 196 feet long, a hotel and restaurant 90 feet by 75 feet, two fabricating shops 360 feet long, a terminal building, a hospital, two garages, two principal storehouses for the fabricating plant, three paint storage buildings, a storehouse for heavy machinery 300 feet long, and a machine shop. Material will be handled throughout the yard by twenty locomotive cranes of from 15 to 25 tons capacity.

All machinery in the yard will be driven by electricity, which will be supplied by the Public Service Company. Fourteen electrically-driven air compressors will be installed, each of sufficient capacity to supply power for the air tools for two hulls.

D. H. Cox, of Cox & Stevens, naval architects, New York, and secretary of the Society of Naval Architects and Marine Engineers, is resident engineer in charge of operations at the plant.

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NEW SHIPBUILDING COMPANIES ORGANIZED

Progress of Work in New Shipyards

The International Shipbuilding Company has been organized at St. Helens, Ore., to build wooden ships.

The Downey Shipbuilding Corporation, 120 Broadway, New York, which owns a shipyard at Milliken, S. I., N. Y., is making extensive enlargements to the plant.

The Union Timber & Products Company, Port Townsend, Wash., will build a wooden shipbuilding yard.

The St. John Shipbuilding Company, St. John, N. B., is preparing plans for a shipyard.

Carl Hartmann, Green Bay, Wis., of the Hartmann-Grenning Company, has organized a shipbuilding company to build a yard at Green Bay, for the construction and repair of steel and wooden vessels.

Walter E. Cabell, Cornelius C. Moore and Walter Curry, all of Providence, R. I., are reported to have secured a large waterfront at Portsmouth, R. I., where they are planning the construction of a shipyard and drydock.

The Coast Ship Company has been organized at Biloxi, Miss. It is reported that the company has already received contracts to build six wooden vessels. The officers are D. J. Gay, president; L. V. Pringle, vice-president, both of Biloxi, and W. A. McInnis, general manager, Gulfport, Miss.

The Henderson Shipbuilding Company has been organized at Mobile, Ala., by Frank Henderson and W. T. Henderson.

The Alabama Dry Dock & Shipbuilding Company, Mobile, Ala., has increased the capacity of its plant.

The Seaboard Barge Company has been organized in Monroe, N. Y., with a capital of $500,000.

The Baldwin Shipbuilding Company has been organized at New Baltimore, N. Y. S. & W. H. Baldwin, 30 Broad street, New York, are among the incorporators.

The Fort Mifflin Shipbuilding Company, which was organized in Philadelphia some time ago, with a capital stock of $10,000,000, is stated to have perfected plans for the construction of a shipbuilding plant on the Delaware River.

The Perry Motor Boat Company has been organized in Buffalo. N. Amigone and J. & P. Orlando, Buffalo, are the incorporators.

It is reported that the North Carolina Shipbuilding Company, Morehead City, N. C., will shortly erect a shipbuilding plant. It is said to have secured a Government contract to build several vessels.

The Gulf-Cuba Corporation has been organized in Apalachicola, Fla., to construct sea-going barges. S. E. Rice, Jr., is the president.

The Atlantic Coast Company, which bought the Townsend Marine Railway & Construction Company, East Boothbay, Me., is planning to build several large schooners.

The York River Shipbuilding Corporation, Mutual Building, Richmond, Va., is beginning the construction of its plant near West Point, Va.

L. H. Shattuck Company, which is building a shipyard at Newington, N. H., has received contracts to build more than a dozen steamers for the United States Shipping Board.

The Lilly-Fletcher Company has been organized at Los Angeles, Cal., to erect a shipbuilding plant. J. B. Lilly, of Los Angeles, is one of the incorporators.

The New York, San Francisco & Hong Kong Steamship Company, San Francisco, Cal., has bought 10 acres of land at Redwood City, with the reported purpose of erecting a shipbuilding plant.

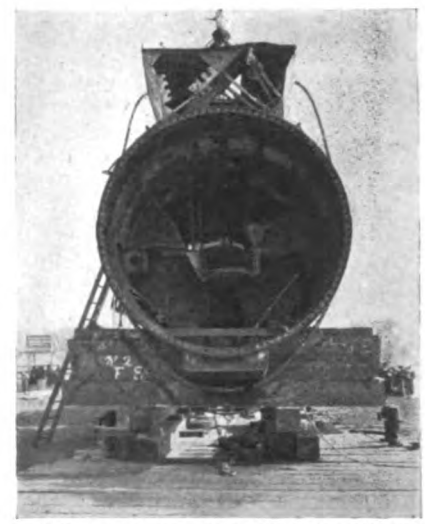
The Sommarstrom Shipbuilding Company has been organized in San Francisco, Cal., by M. F. Sommarstrom and others.

The Eastern Shore Shipbuilding Corporation, of which R. R. Livingston, 2 Rector street, New York, is president, has acquired a shipbuilding plant at Sparrows Point, Md., and will erect additional buildings, for which new equipment will be required.

One shipbuilding ways has been com-

(Photograph by Albert Cook Church, New Bedford, Mass.)

Fig. 1.—Captured German Submarine, Exhibited at Central Park, New York



(Photograph by Albert Cook Church, New Bedford, Mass.)

Fig. 2.—Interior of German Submarine

(Photograph by Albert Cook Church, New Bedford, Mass.)

Fig. 3.—Bow View of Captured German Submarine

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pleted by V. C. & J. E. Scott, of Mobile, Ala., for their shipyards announced last May. Five other ways will be added as needed, with facilities for constructing wooden vessels. A 100 by 50-foot building, of mill construction, with 25 by 20-foot boiler room, has also been completed and the machinery is in position. This machinery includes band-saws, planers, hoists, compressed air boring and hammering equipment. The plant is at Shellbank, on Chickasaw Bogue, near Mobile.

Seagoing barges and other vessels will be constructed at Apalachicola, Fla., by the Gulf-Cuba Corporation, which has been chartered, with $50,000 capital. A site has been secured and details are now being determined for the shipyards. It is reported that contracts amounting to $225,000 have already been secured.

The shipbuilding plant on the Niagara River, near Bridgeburg, Ont., which has been closed for several years, will soon be put in operation by the Canadian Allis-Chalmers Company, King and Simcoe streets, Toronto, the holding company of the Canada Foundry Company, Toronto, which has owned the plant for the past ten years. Steel ships of the size to pass through the Welland Canal will be constructed. A force of men will be put to work at once in order to get the yards ready for ship construction at an early date. The plant was constructed in 1903 by the now defunct Canadian Shipbuilding Company, and comprises about 200 acres. Some additional shipbuilding machinery will be purchased.

The Lake Erie Dry Dock & Engineering Company, Sandusky, Ohio, has been formed, with a capital stock of $11,600,000, to take over the plant of the Lake Erie Dry Dock & Mill Company, and probably other plants of that city. Chas. Bright and others are interested in the new company, which, it is stated, will engage in shipbuilding work.

The Pennsylvania Shipbuilding Corporation, Gloucester City, N. J., has increased its capital from $1,000,000 to $2,500,000.

Trained Navigators and Marine Engineers Graduated from New York State Nautical School

The forty-second commencement of the New York State Nautical School took place on October 13 on the recreation pier at the foot of 129th street, North River, New York, where the schoolship *Newport* is now berthed. Thirty-one cadets, nineteen in the deck and twelve in the engineering division, received diplomas, which were presented by Dr. John H. Finley, State Commissioner of Education. Certificates of graduation were presented by Captain George L. Norton, member of the Board of Governors of the school.

The officers of the *Newport* are Captain Felix Riesenberg, superintendent; C. E. Morgan, executive officer; Commander C. M. Matthews, U. S. N. (retired), chief engineer; Gershom Bradford, navigator; D. C. C. Craft, surgeon, and Junior Officer E. R. Glosten.

(Photograph by Edwin Levick.)

S. S. *Stian*, Second Vessel Launched by Standard Shipbuilding Corporation at Shooters Island, N. Y.

Sailing Vessels Barred from the War Zone

American sailing vessels have been prohibited from commerce in the war zone. The United States Shipping Board has instructed the Bureau of Export Licenses not to grant licenses for goods to be shipped through the war zone on sailing vessels.

Sailing vessel owners will have no difficulty, however, in chartering their vessels for voyages to South America, South Africa, in the coastwise trade or for other runs.

Personals

H. R. ALEXANDER, president of the Pacific Steamship Company, has been elected a member of the Board of the American Steamship Association.

WILLIAM A. BATTEY, Eastern sales manager and sales director of the Shepard Electric Crane & Hoist Company, Montour Falls, N. Y., will sever his active connection with the business on December 1, but will retain his interest in the company and continue as a director. He will be succeeded by W. C. Briggs as district manager and Robert T. Turner as sales engineer.

CAPT. WILLIAM MATSON, president of the Matson Navigation Company and Sweden's Consul-General, died recently in San Francisco.

JOHN T. HEFFERNAN, president and treasurer of the Heffernan Engine Works, Seattle, has been called to Washington for work in connection with the Shipping Board Emergency Fleet Corporation. Mr. Heffernan is associated with the American International Corporation, which owns the New York Shipbuilding Corporation, and is putting up the fabricated steel shipbuilding plant at Hog Island, Philadelphia.

DR. ALEXANDER HAMILTON RICE, explorer, has been commissioned second lieutenant in the United States Naval Reserve force, and will become a member of the faculty at the cadets' school of the Second Naval District.

J. C. CRAVEN, formerly in the hull estimating department of the Newport News Shipbuilding & Dry Dock Company, has been appointed naval architect with the United States Steel Corporation.

C. T. PUTSELL, formerly with the Newport News Shipbuilding & Dry Dock Company, has been appointed chief hull draftsman of the Amens Company, San Francisco, Cal.

H. G. HOUSE, formerly with the Skinner & Eddy Shipbuilding Corporation, Seattle, Wash., has been appointed naval architect of the Albina Engine & Machine Works, Portland, Ore.

C. W. JOHNSON, general superintendent of the East Pittsburg Works of the Westinghouse Electric & Manufacturing Company, has been elected vice-president of the American Institute of Metals.

BENJAMIN D. FULLER, of Cleveland, superintendent of foundries of the Westinghouse Electric & Manufacturing Company, has been elected president of the American Foundrymen's Association.

Edward O. Cutler, formerly assistant superintendent of the Bath Iron Works, Bath, Me., and more recently assistant manager of the Craig and California Shipbuilding Companies, Long Beach, Cal., is now assistant to the president of the Groton Iron Works, Groton, Conn., where a splendidly equipped new shipyard is being built for the construction of both wooden and steel vessels. The company now has contracts for twelve wooden steamers and six 9,000-ton steel steamers.

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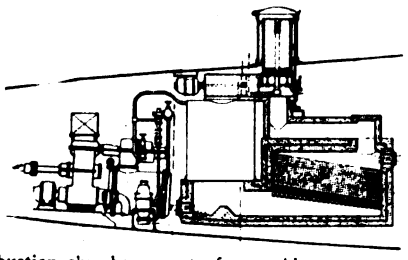
SELECTED MARINE PATENTS

The publication in this column of a patent specification does not necessarily imply editorial commendation.

American patents, compiled by Delbert H. Decker, Esq., registered patent attorney, Millerton, N. Y.

1,226,220. POWER-DEVELOPING APPARATUS. ALEXANDER T. KASLEY, OF SWISSVALE, PA., ASSIGNOR TO THE WESTINGHOUSE MACHINE COMPANY, A CORPORATION OF PENNSYLVANIA.

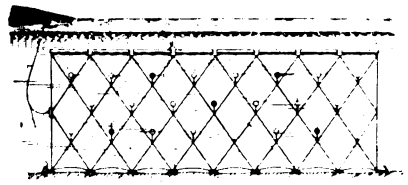
Claim 10.—In a power plant for submarines, a fluid pressure generator, a furnace having a combustion chamber in proximity with said generator, a second furnace having a com-



bustion chamber remote from said generator, a heat storing apparatus located between and forming a means of communication for said combustion chambers, a stack communicating with the off-take of said generator and serving both furnaces, means of communication between the off-take and said apparatus, and means for shutting off communication between the stack and the off-take and for establishing communication between the off-take and the apparatus for the purpose of delivering heat from the apparatus to the generator, and means for creating a continuous flow of heat carrying fluid, through the heat storing apparatus, the generator, the off-take and back to said apparatus. Fourteen claims.

1,226,348. SUBMARINE MINE AND PROPELLER ENTANGLEMENT. ARTHUR N. McGRAY, OF NEW YORK, N. Y.

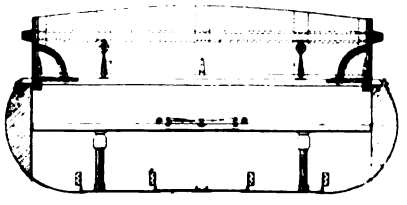
Claim 1.—A submarine defense comprising a plurality of looped propeller entanglements, an anchoring cable, and a connection extending from the bottom of each loop to the cable,



each loop having float means for co-operating with the cable to maintain the loops more or less upright, and the float means also serving to hold the loops open for entanglement with propellers, said loops being independent of each other and free to move laterally in all directions from the anchoring cable. Two claims.

1,226,944. LIFE BOAT AND THE LIKE. HARRY W. BROADY, OF BAYSIDE, N. Y., ASSIGNOR TO WELIN MARINE EQUIPMENT COMPANY, A CORPORATION OF NEW YORK.

Claim 1.—A metallic nestable life-boat embodying a rigid shell having a well polygonal in conformation to permit immediate loading and a superstructure formed of rigid side and



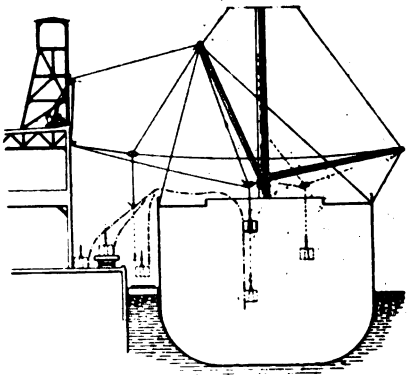
end members adapted to be raised and lowered relatively to the shell, means for automatically locking such side and end members when the same are moved into vertical position and an independent lock for alining the meeting edges of such side and end members and securely locking the same together. Two claims.

1,223,536. TORPEDO SHIELD FOR VESSELS. JOHN O. TRAVELSTEAD, OF PENDLETON, OREGON.

Claim 1.—The combination with a vessel, supporting means extending substantially longitudinally from the bow and stern ends of the vessel, shield members supported by said supporting means and laterally extending from opposite sides thereof for protecting the ends of the vessel, and other shields movably connected to the sides of the vessel and co-extensive therewith and having their ends connected to one of said laterally extending shields, said laterally extending shields being shiftable. Six claims.

1,228,344. LOAD-TRANSFER APPARATUS. THOMAS SPENCER MILLER, OF SOUTH ORANGE, N. J., AND LOUIS G. RUGGLES, OF NEW YORK, N. Y.; SAID RUGGLES ASSIGNOR OF HIS ONE-HALF TO LIDGERWOOD MANUFACTURING COMPANY, A CORPORATION OF NEW YORK.

Claim 10.—In a load-transfer apparatus, in combination, an elevated support, two hoisting ropes suspended from a common point on said support, a winding engine for each of said ropes, connections between said engines whereby said ropes may be taken up and paid out



simultaneously or independently of each other, a swinger frame engaging a fall of each of said ropes, and means for simultaneously swinging said frames in opposite directions to each other to swing said ropes laterally in opposite directions on said point of common support. Twelve claims.

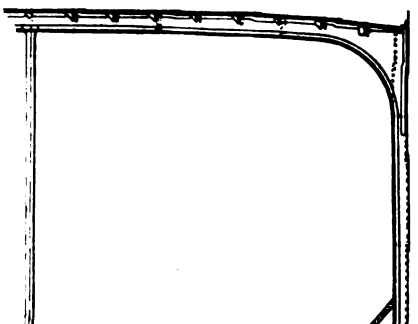
1,223,627. SHIP-PROTECTING SHIELD. WILLIAM A. SHEPHARD, OF WAUKESHA, WIS.

Claim 1.—A submersible shield for protecting ships comprising a frame, vertically disposed sheathing plates carried by the frame having their edges overlapped and spaced apart, arms having ends in hinged connection with the upper portion of the frame means for hingedly connecting the opposite ends of the arms to the sides of the vessel, and means for raising and lowering the shields. Two claims.

British patents compiled by G. F. Redfern & Co., chartered patent agents and engineers, 15 South street, Finsbury, E. C., and 10 Gray's Inn place, W. C., London.

106,124. "IMPROVEMENTS IN AND RELATING TO SHIPS' FRAMING." W. MILLAR, DIRECTOR OF THE GREENOCK AND GRANGEMOUTH DOCKYARD COMPANY, LTD., SHIPBUILDERS, GREENOCK, SCOTLAND.

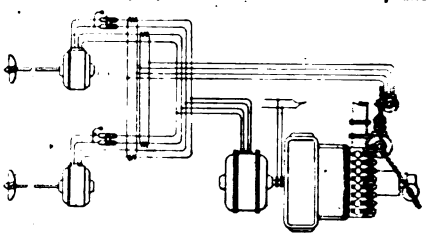
This invention relates to framing for ships, and it has for its object to provide an arrange-



ment or system adapted to give speedy erection and to save cost of labor and reduce the weight of material while providing without obstructions clear holds for cargo. It provides an improved system of the type in which transverse framing is combined with pillar beams and fore-and-aft stiffening for decks and bottoms of vessels. The vessel is built with ordinary side frames and with strong reinforced side frames, which are placed at suitable distances apart and are composed of any suitable sections, or may be of plate or lattice form. The reinforced frames are so constructed and arranged that they do not project into the hold of the ship. At the bottom thereof the ordinary frames and the reinforced frames are connected to the tank top with brackets and angles or the like or to the tank margin, as the case may be. Connected to each of the reinforced frames is a strong pillar beam slotted at suitable intervals to carry fore-and-aft stiffening sections forming the deck supports. The angles in these strong pillar beams are intercostal and are connected to the deck plating.

108,046. SYSTEMS OF SHIP PROPULSION. THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, OF 83, CANNON STREET, LONDON, E. C., ELECTRICAL ENGINEERS AND MANUFACTURERS.

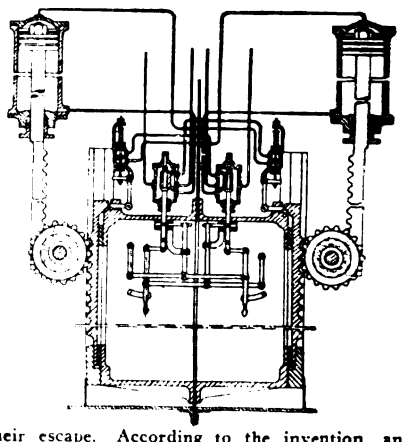
This system of electric ship propulsion comprises alternating current motors coupled to the shafts of propellers on each side of ship and



receiving current from a turbine-driven, alternating current generator and means for preventing an increased admission of motive fluid to the turbine to accommodate for any increase in load on either of the motors when the ship's motion is in the arc of a circle.

106,647. IMPROVEMENTS IN WATER-TIGHT DOORS FOR THE BULKHEADS OR PARTITIONS OF SHIPS, SUBMARINE VESSELS, CAISSONS, DIVING APPARATUS AND THE LIKE." ENGINEER LIEUTENANT I. TORO, CHILIAN NAVY, OF 22, WOLSELEY GARDENS, JESMOND, NEWCASTLE-ON-TYNE, IN THE COUNTY OF NORTHUMBERLAND.

This invention has for its object to provide a water-tight door for the bulkheads or partitions of ships, submarine vessels, caissons and the like to allow of persons easily making their escape from one compartment to an adjoining compartment without at any time allowing the watertightness of the bulkhead to be impaired, and thereby preventing water flowing through in sufficient quantity to endanger the safety of the vessel or the lives of the persons making



their escape. According to the invention, an opening is cut in the bulkhead, and to this opening is fitted, in a water and air-tight manner, a chamber or cell of rectangular or other suitable shape. This cell is formed by two rigid cast steel frames of the required dimensions, to enable one or more to move about in the cell. It has two openings, through which men can pass, and each of these openings is fitted with a sliding door adapted to slide in ways to and from the seat so that, when open, there is a clear entrance into the chamber, or when closed, a wedge-shaped edge on the doors enters between correspondingly shaped faces or into the recess in the seat or sill of the opening, thus forming a watertight joint to prevent leakage and render the doors self-packing. These doors can be operated hydraulically, pneumatically, electrically or otherwise in such a way that under no circumstance whatever can both be opened at the same time.

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